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GAS REQUIREMENTS TO PRESSURIZE ABANDONED DEEP MINES

John D. Robins

Environmental Protection Agency
Washington, D. C.

August 1973

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While pressurization tests conducted at the larger (50 acres) test mine site were generally inconclusive, the final test results obtained at the smaller (15 acres) mine site were encouraging. Slight positive differential mine pressure could be maintained over extended periods of time at air injection rates as low as 150 cfm. It was also found that barometric pressure fronts had little or no effect on differential mine pressures and that mine pressure differentials immediately dissipated at the cessation of air injection. The experimental data collected throughout this study is presented in the Appendix. (EPA)

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GAS REQUIREMENTS TO PRESSURIZE ABANDONED DEEP MINES

By

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ABSTRACT

The objective of this study was to determine the gas injection rates needed to develop and maintain slight pressures within a mine over ambient conditions during changes in the barometric pressure. The ultimate aim of the project was to determine the feasibility of blanketing an abandoned deep mine with an inert gas in order to eliminate the acid mine drainage. Pressurization tests were conducted at two typical abandoned deep mine sites in southwestern Pennsylvania. The study also included a state-of-the-art evaluation of existing technology which could be used to locate points of gas leakage from deep mines. The findings of this literature survey were implemented in several full-scale leak detection experiments.

While pressurization tests conducted at the larger (50 acres) test mine site were generally inconclusive, the final test results obtained at the smaller (15 acres) mine site were encouraging. Slight positive differential mine pressures could be maintained over extended periods of time at air injection rates as low as 150 cfm. It was also found that barometric pressure fronts had little or no effect on differential mine pressures and that mine pressure differentials immediately dissipated at the cessation of air injection.

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SECTION I
CONCLUSIONS

The data obtained during the investigative portion of this study was insufficient to accurately project the gas injection requirements to pressurize an adequately sealed abandoned deep mine. However, data collected at the experimental test mine sites can substantiate the following:

1. Positive pressure differentials could be maintained within the King No. 2 mine at relatively low air injection rates (150-175 cfm).

2. Both test mines are free-breathing, i.e., under normal conditions pressure differentials were not developed within either of the mines during barometric pressure fronts.

3. Pressure differentials within the King No. 2 mine, as developed and maintained through air injection, were not affected by normal barometric pressure changes regardless of the air injection rate.

4. Air injection must be continuous in order to maintain a positive differential pressure within the mines investigated.

General observations throughout the course of this study lend support to the theory that this method of acid mine drainage abatement is not economically feasible where any of the following conditions exist.

- Shallow overburden
- Mines which have been intercepted by extensive contiguous operations
- Areas of extensive fractureing and subsidence
- Inadequate coal barriers between the outcrop coal or adjacent surface or deep mines

SECTION II
RECOMMENDATIONS

The results of this study indicate that slight pressures can be developed and maintained within a relatively free-breathing deep mine at low air injection rates. It is recommended that this study be continued to optimize the gas injection requirements in relatively "tight" deep mines.

It is also recommended that a study be conducted to determine the geographical locations and percentage of mine sites to which this method of acid mine drainage abatement may be economically feasible.

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SECTION III
INTRODUCTION

General Background

The formation of acid mine drainage is a naturally occurring phenomenon that results when pyrites are exposed to air and water. Pyrites, which are minerals containing iron sulfide, generally occur in association with various minerals and ores; such as coal, copper, gold, sulfur, etc. The mining of these minerals and ores, either by surface or subsurface methods, exposes the pyritic materials which subsequently oxidize in the presence of moisture and air to form sulfuric acid and ferrous sulfate. These salts then dissolve in ground or surface waters to form dilute solutions of sulfuric acid and iron sulfate commonly known as "acid mine drainage."

The complete mechanisms of this chemical reaction are not entirely understood, but the overall reaction can be shown as:

$$2FeS_2 + 2H_2O + 7O_2 \longrightarrow 2FeSO_4 + 2H_2SO_4$$

$$\text{(pyrite)} \longrightarrow \text{(ferrous sulfate)} + \text{(sulfuric acid)}$$

The ferrous sulfate will oxidize to the ferric form, which then hydrolyzes to form either ferric hydroxide or ferric sulfate, producing a condition in surface streams called "Yellowboy."

The overall result of the oxidation of pyrites is the formation of acid mine drainage, a major source of pollution in the Eastern and Mid-Atlantic states created by coal and other mineral mining. Although the acid water can be neutralized, measures for preventing the formation of acid in subsurface mining operations have not been developed.

The primary technique for abating or preventing the oxidation of pyrites in deep mines is the elimination of oxygen by either flooding the mine with water or to seal its openings, thus preventing the entrance of fresh air. This preventive technique was widely employed by the Works Progress Administration under the direction of the United States Public Health Service during the 1930's. It is estimated that more than 20,000 seals[1] were constructed by

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this Administration, in order to prevent the discharge of acid mine drainage as well as for other reasons. Although the results of this program are poorly documented in the literature, the information available indicates a substantial reduction in acid pollution. Later work was conducted by S. A. Braley[2] at the Mellon Institute of Industrial Research, Pittsburgh, Pennsylvania, on the prevention of acid formation in deep mines by elimination of oxygen.

Braley's[3] laboratory work further documented this theory when he showed a substantial reduction in the amount of acid formed by controlling the oxygen content in the atmosphere contacting "sulfur ball" pyrite of -8 + 40 mesh in laboratory flasks. He proportioned various mixtures of oxygen and nitrogen and passed these atmospheres through the flasks for two weeks. The amount of acid and sulfate was determined by washing the pyrites with distilled water. His results were as follows:

	$100N_2$	$99.6N_2$	$92N_2$	$90.8N_2$	$82.9N_2$	Air	$0N_2$
Atmosphere Comp.	$0\ O_2$	$.4\ O_2$	$8\ O_2$	$9.2\ O_2$	$17.1\ O_2$	0	$100\ O_2$
Acid ($CaCO_3$ eq.)	31	30	440	476	948	1104	2903
SO_4	34	37	447	494	931	1082	2900

From this work he postulated that there should be no acid formed in an atmosphere consisting of 100% N_2 and any decrease in the oxygen concentration in a mine should decrease the extent of acid formed. Subsequent studies by Bell[4] and Troy and Robins[5] have further demonstrated that the acid production of coal mine pyrites is proportional to the oxygen partial pressure in the gas phase in contact with the pyrite.

The mine sealing program had limited success in eliminating the acid discharges. The seals generally failed to stop the flow of water; however, many wet seals were successful in preventing air from entering the mine while allowing the drainage to leave. The air retained within the mine, at the time of sealing, was slowly depleted of oxygen by the oxidation reactions and when such was complete, the production of ferrous sulfate and sulfuric acid slowly diminished. The faulure of the sealing program in many instances was as much the result of the inability to prevent all air from entering the mines as it was of the difficulty of maintaining the effectiveness of the seals. Subsidence fractures in the rock strata above the seam, in addition to the natural fissures present, meant that sealing the main entrances and even filling the subsidence areas could only reduce but never eliminate air from entering the mine.

Scope of Study

Based on this previous work, it has been recognized that if the atmosphere in abandoned deep mines could be maintained in an inert condition; that is, free from oxygen, the formation of acid by the oxidation process would be stopped and the production of acid mine drainage effectively eliminated. It is surmised that such a condition could be maintained if one could inject a non-oxidizing gas into abandoned mines and maintain this inert condition by creating a slight positive pressure within the mine over the outside ambient conditions. It is known that deep mines "breathe" during barometric changes in the atmosphere. If such a slight pressure could be developed and maintained within the mine, it would then be in a constant state of exhaling, thus preventing the influx of air and oxygen into the mine.

This study was intended to be the first phase of a complete inert gas blanketing demonstration project. Phase I involved the pressurization of abandoned deep mines with air to determine the gas injection rates required to maintain positive pressures within the mine during normal barometric changes.

The theoretical calculations for sizing the air blowing equipment are discussed in Section V - System Parameters and Engineering Calculations, of this report. The free-breathing rate of the mine selected for this study was estimated and the equipment used was sized slightly above this rate. The purpose was to select a mine that was reasonably "tight," in order that the air flow would only be through the existing entries and not through unlocated potholes or fissures. For these reasons, the Whipkey deep mine in Ohiopyle State Park, Fayette County, Pennsylvania, was selected as the initial site for the study. Additional work under this study was also conducted at the nearby King No. 2 deep mine. The physical characteristics and history of both of these mines are discussed in Section IV - Demonstration Mines.

SECTION IV
DEMONSTRATION MINES

Whipkey Deep Mine

The mine first chosen for this study is known as the Whipkey Mine and is located in Stewart Township, Fayette County. The mine was originally opened in 1938 and presently encompasses 60 Hectares (150 acres) of which 20 Hectares (50 acres) is estimated to have been mined. The coal seam mined was the Lower Kittanning which has an average thickness of 91 centimeters (36 inches) in this area. The interval between the Middle Kittanning and Lower Kittanning coal seams is generally characterized as being a massive sandstone and, in this particular case, the sandstone is fine grained with a relatively low porosity. The coal outcrops near the base of a steeply sloping hillside and the overburden above the coal seam rapidly increases to approximately 84 meters (275 feet). The coal seam dips to the southeast at a slope of approximately 6% and the strike of the coal is to the northeast. A section of a 7.5 minute U.S.G.S. topographic map showing the location of the Whipkey and King No. 2 mine sites appears in Figure No. 1. A blow-up of this area showing the extent of the Whipkey deep mine appears in Figure No. 2.

The mine was first opened in the southeast section of the property boundary which is now the lowest point of the mine. As mining progressed, new entries were driven to the west of the original entries along the southern boundary of the property line. Wherever possible, the coal was mined to the rise to permit gravity drainage from the mine as well as to develop the most advantageous haulage courses. A total of eleven entries were driven into the mine during the period of its inception in 1938 to its closing in 1964.

The southern boundary of the Whipkey mine was strip mined in 1960. The strip mine operator cut into the Whipkey mine in at least five places and, in at least two of these instances, extensively fractured the roof of the deep mine. Figure 3 shows a aerial photograph of the hillside containing the Whipkey deep mine, and also the strip mined

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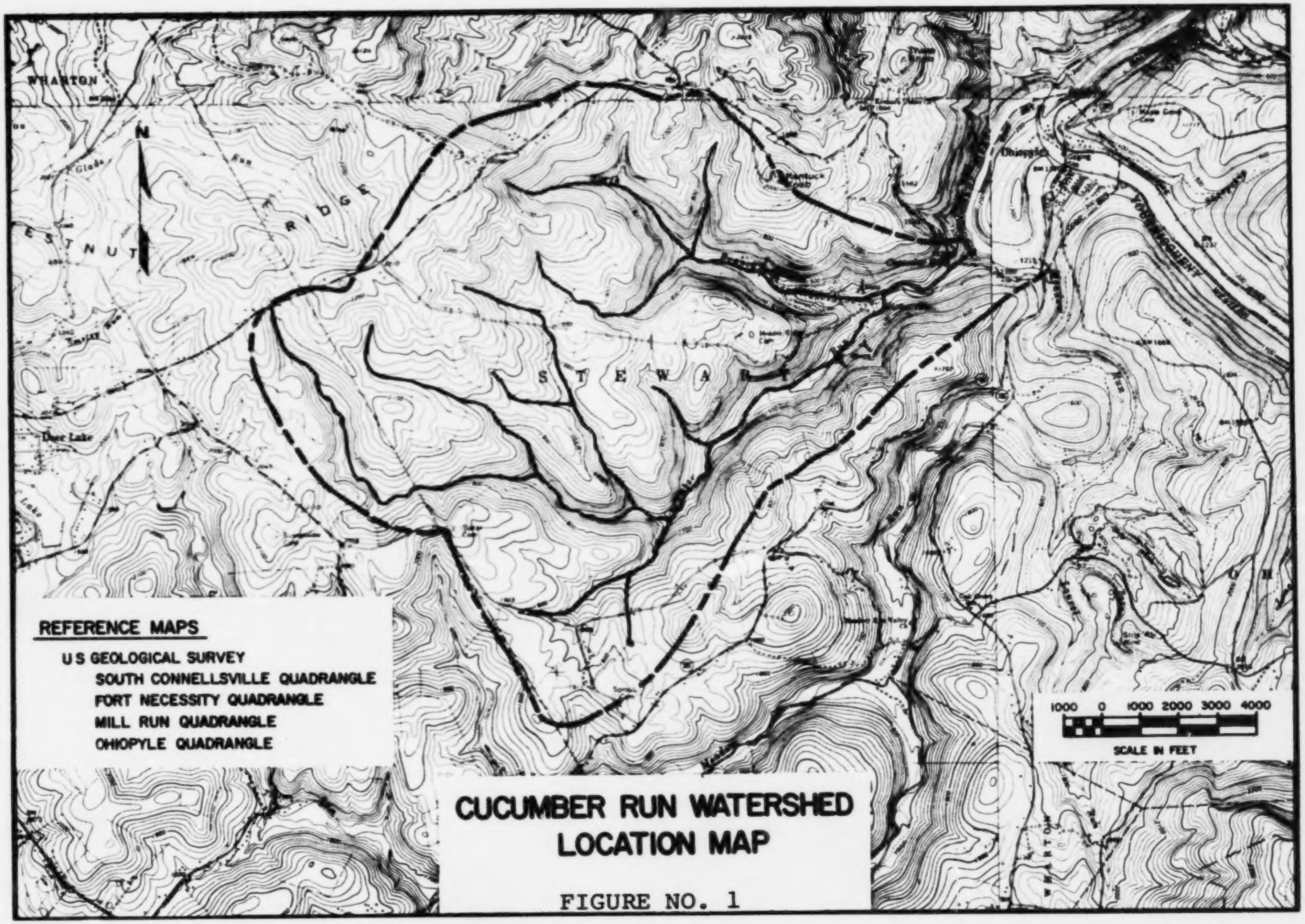
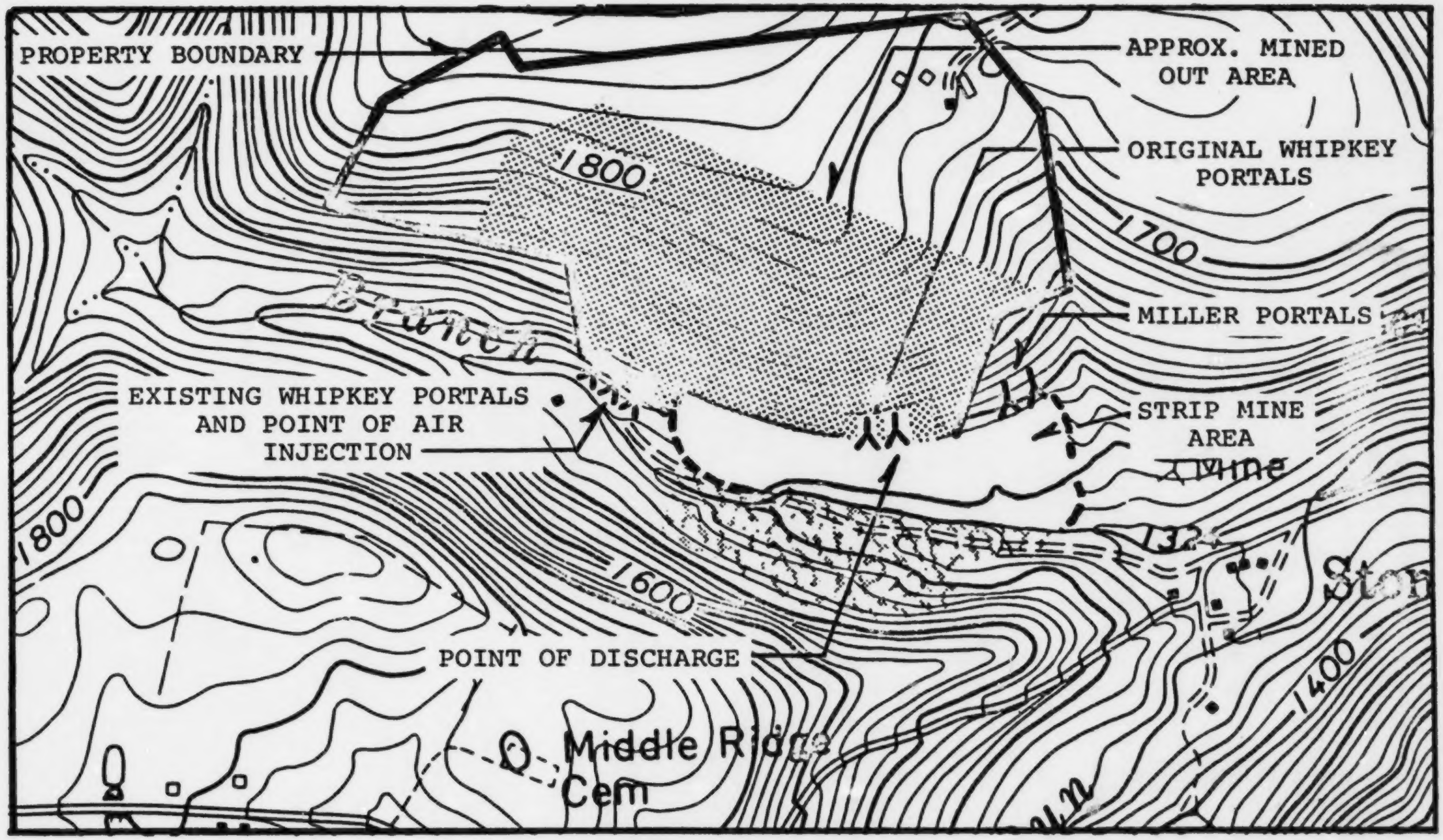

REFERENCE MAPS
US GEOLOGICAL SURVEY
SOUTH CONNELLSVILLE QUADRANGLE
FORT NECESSITY QUADRANGLE
MILL RUN QUADRANGLE
OHIOPYLE QUADRANGLE
1000 0 1000 2000 3000 4000
SCALE IN FEET
N
WHARTON
STEWART
CHESTNUT RIDGE
Ohiopyle

CUCUMBER RUN WATERSHED
LOCATION MAP

FIGURE NO. 1


PROPERTY BOUNDARY
APPROX. MINED OUT AREA
ORIGINAL WHIPKEY PORTALS
1800
1700
MILLER PORTALS
Branch
EXISTING WHIPKEY PORTALS AND POINT OF AIR INJECTION
STRIP MINE AREA
Mine
1800
132
1600
Sto
POINT OF DISCHARGE
1400
Middle Ridge Cem

WHIPKEY DEEP MINE PLOT PLAN

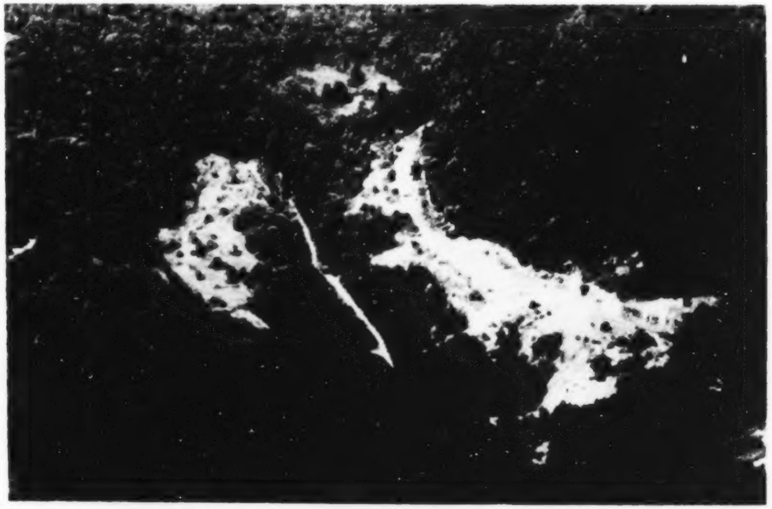
FIGURE 2

area and the approximate location of the entries. Figures 4 through 8 are photographs of the existing three openings into the upper portion of the Whipkey mine both before and after construction of dry seals.

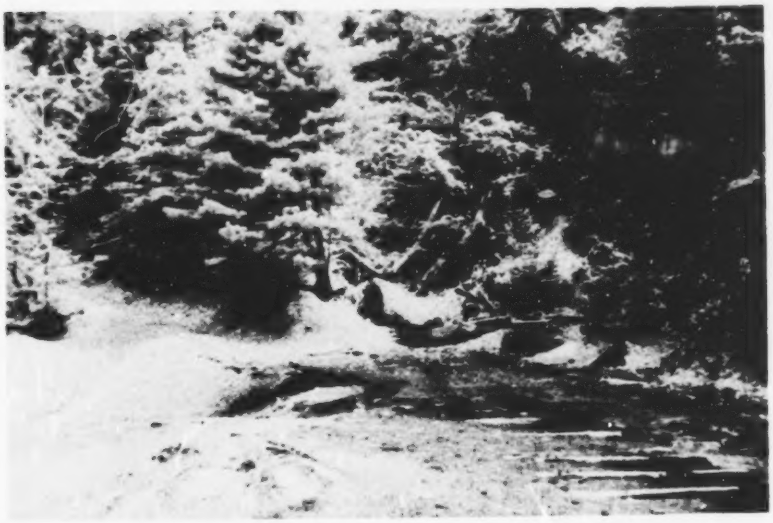
In 1961, another small mine, known as the Miller mine, was opened directly adjacent to the southeast section of the Whipkey mine. The mine was never developed to any great extent; however, at one time the operator cut deeply into a barrier pillar between a flooded portion of the Whipkey mine, and, as a result, temporarily flooded the Miller mine.

In 1964, the Western Pennsylvania Conservancy purchased the coal and surface rights of the Whipkey mine. Although the Conservancy was able to purchase the coal rights of the Miller mine, they have been unable to obtain the surface property to date. The Conservancy then funded money for the backfilling and revegetation of the strip mined area; however, this could be accomplished only as far as the Miller mine since the surface area was still privately owned. The strip mined area was backfilled to a maximum depth of approximately 1.2 meters (four feet) above the Whipkey deep mine. At the time the strip mine was being backfilled, a wooden flume was installed at the original Whipkey mine entry to prevent water from accumulating in the deep mine. The previous release of a large slug of acid water, through the Miller mine created serious problems in downstream public water plants. This wooden flume was still in use and had an average flow of 2.5 liters per second (40 gpm) in the summer months and approximately 1 liter per second (15 gpm) throughout the winter during the course of this study. Analyses of the Whipkey mine discharge are tabulated in Table 1.

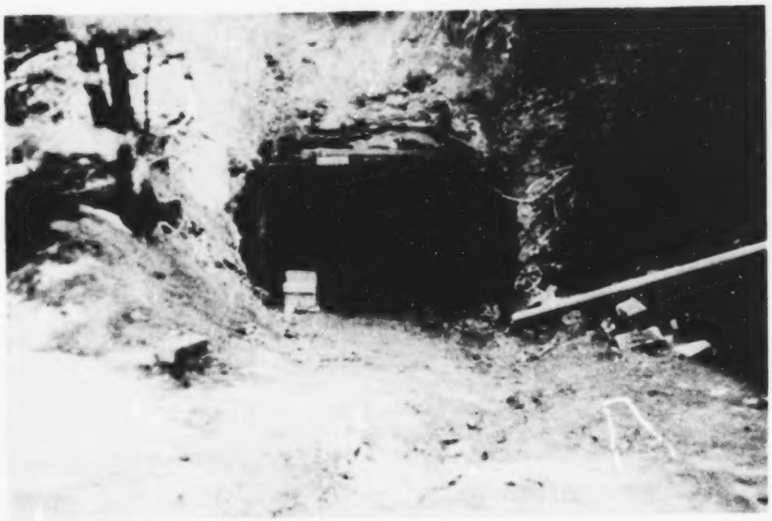
In the fall of 1969, the State of Pennsylvania entered into a contract with E. D'Appolonia Consulting Engineers, Inc., to perform surface and sub-surface explorations in the Cucumber Run watershed. The purpose of these explorations was to expose all known mine entries and to locate openings into the deep mines caused by strip mining operations, and, ultimately, to design seals for each of these openings. The results of these sub-surface explorations are discussed in Section VII - Project Operation and Results.


EXISTING WHIPKEY PORTALS AND POINT OF AIR INJECTION
ORIGINAL WHIPKEY PORTALS
PRESENT DRAINAGE COURSE
MILLER PORTALS

WHIPKEY TEST MINE SITE
FIGURE 3

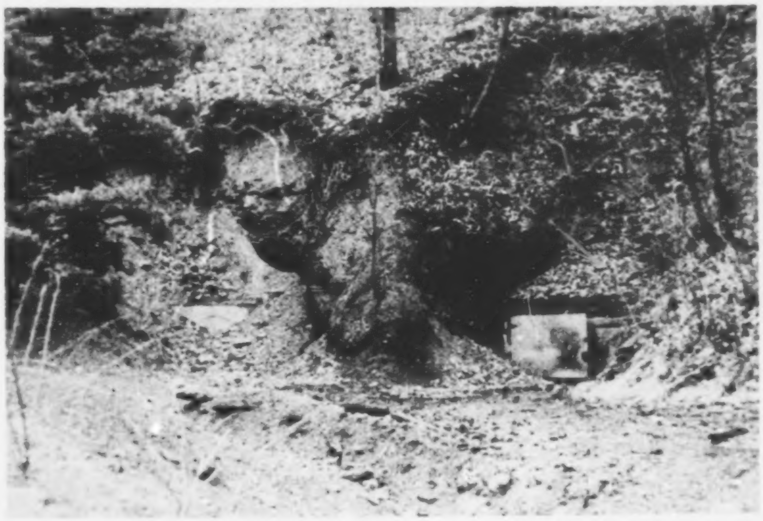


MAIN PORTAL OF WHIPKEY MINE BEFORE SEALING
MAY, 1968
FIGURE 4

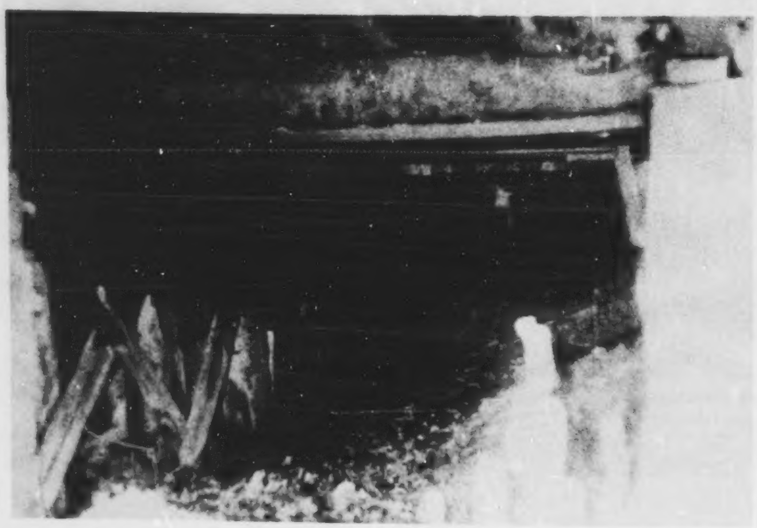


MAIN PORTAL OF WHIPKEY MINE AFTER REOPENING AND SEALING
AUGUST, 1968
FIGURE 5

MAIN AND LOWER PORTALS OF WHIPKEY MINE
JANUARY, 1973
FIGURE 6



WHIPKEY MINE AIR SHAFT BAFORE SEALING
SHOWING REFUSE BUT LITTLE ROOF FRACTURING - JANUARY, 1968
FIGURE 7



WHIPKEY MINE LOWER PORTAL PRIOR TO SEALING
JANUARY, 1968
FIGURE 8

TABLE 1
WATER QUALITY ANALYSES
WHIPKEY MINE DISCHARGE

Date	6/10/68	1/6/70	2/25/70	1/28/71	5/26/71
Flow (gpm)	-	25	20	25	20
M. O. Alkalinity ($CaCO_3$)	0	0	0	0	0
Total Acidity (CaCO3)	1278	660	1000	844	750
Conductivity (25°C) mmhos	-	-	-	-	2450
pH (Electrometrically)	2.6	2.7	2.6	2.6	2.6
Calcium (Ca)	-	-	-	20.8	59
Magnesium (Mg)	-	-	-	11.5	45
Total Hardness ($CaCO_3$)	-	540	650	100	336
Sulfate (SO_4)	-	991	1059	1100	999
Ferrous Iron (Fe)	200	28	26	202	178
Total Iron (Fe)	250	50	77	202	210
Aluminum (Al)	-	-	38	39	-
Mananese (Mn)	-	-	3.5	5.7	-

The discharge from the Whipkey mine enters a tributary of Cucumber Run. Below the confluence of these two streams is Cucumber Falls, a scenic point of interest in the Ohiopyle State Park (see Figure 9). In the early 1960's, Cucumber Run became grossly polluted with acid mine drainage. Approximately 80% of the present pollutional load of Cucumber Run is estimated to originate from the Whipkey deep mine.

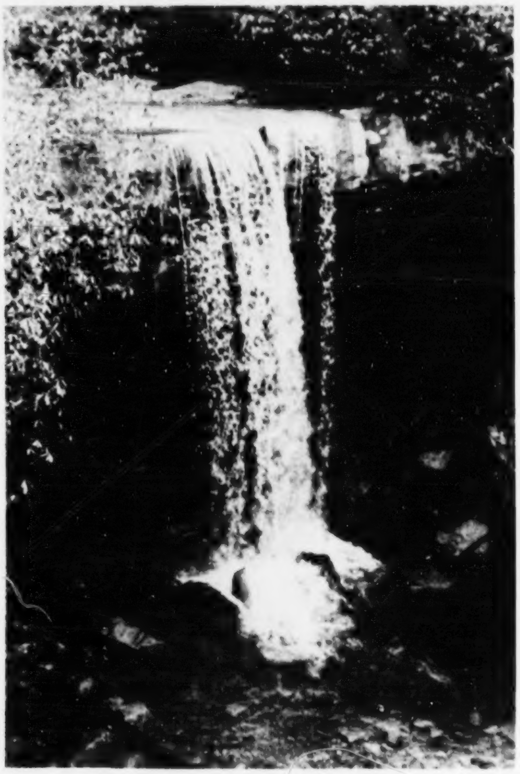
King No. 2 Mine

The King No. 2 mine was opened in 1959 and encompassed approximately 22 Hectares (56 acres) of which 6 Hectares (15 acres) is presently thought to have been mined. The coal seam was the Lower Kittanning, which, as previously described, has an average thickness of 91 centimeters (36 inches) in this area. The coal outcrops near the base of a steeply sloping hillside and the overburden above this mine varies up to approximately 52 meters (170 feet). A blow-up of the 7.5 minute U.S.G.S. topographic map of this area appears in Figure 10 and shows the location, extent of mining and entries of the King No. 2 mine.

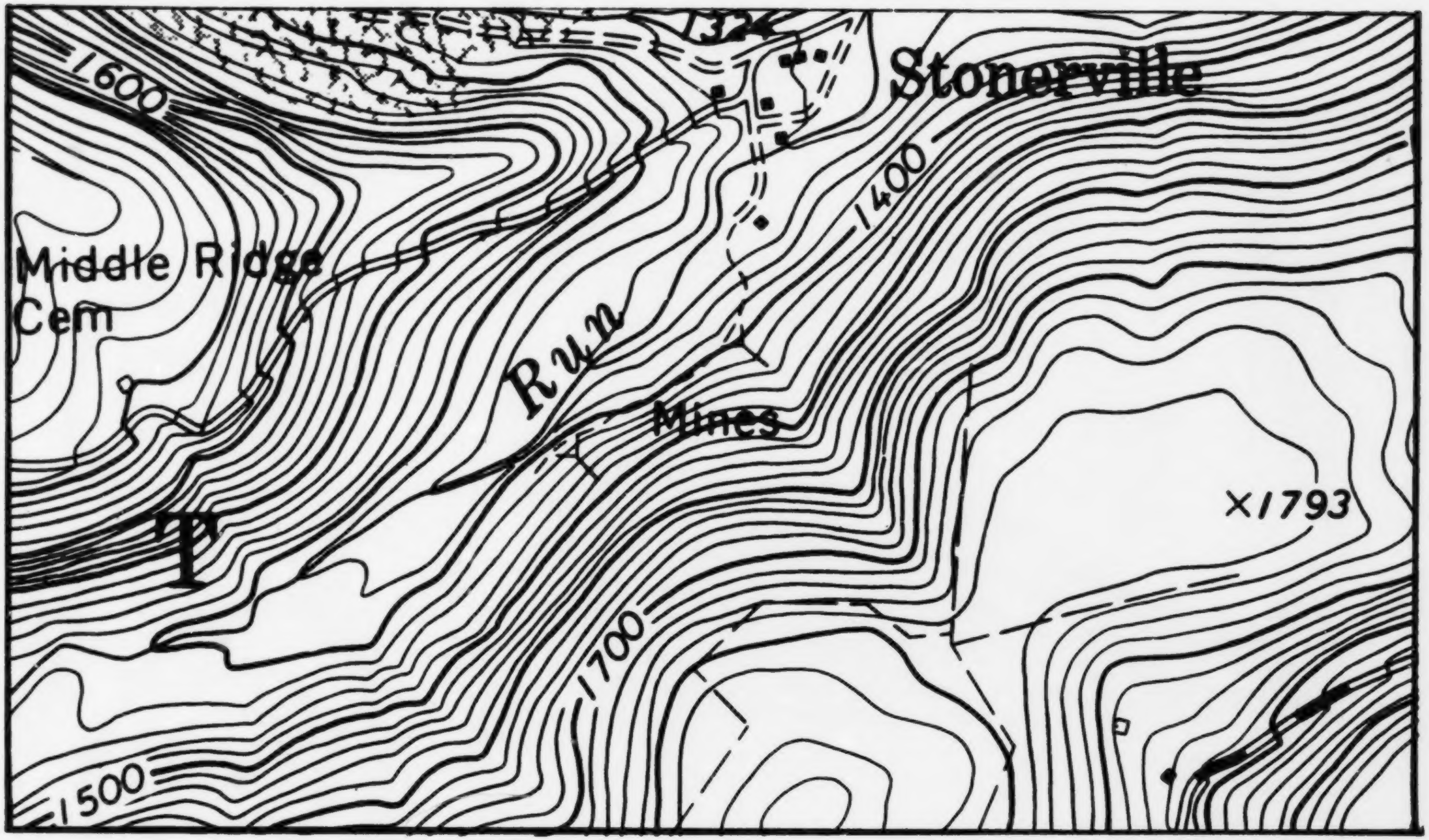
The mine was first opened in the northeast section of the property which is now the point of drainage from the mine. As the mine developed, three additional entries were driven to the southwest of the original entries in order to shorten the haulage route. Mining was developed to the rise to permit gravity drainage from the mine and for ease of coal removal. Figures 11 and 12 are photographs of the middle entry which was used as the point for air injection during this study.

In 1961, a strip mine operator began to remove overburden from the coal seam along the northwest border of the mine. Although this operator did not strip any coal, he did cut into a haulage tunnel at the northwest edge of the deep mine. This section of the haulage tunnel was then filled and the strip mine was not further developed. A typical view of the overburden above the mine appears in Figure 13 which is a photograph of the strip mine highwall approximately 91 meters (300 feet) southwest of the portal used for air injection.

In 1964, the Western Pennsylvania Conservancy purchased the coal and surface rights of the King No. 2 mine. The Conservancy then funded money for the sealing of the deep

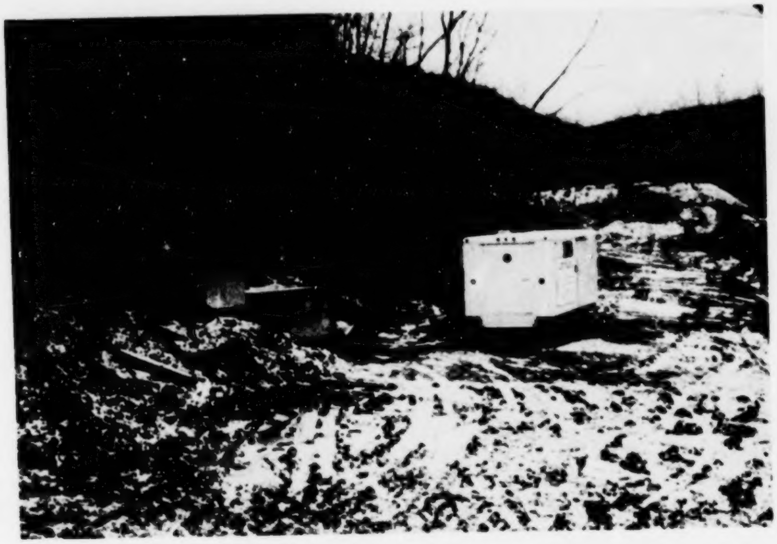


CUCUMBER FALLS, OHIOPYLE STATE PARK
JANUARY, 1973
FIGURE 9

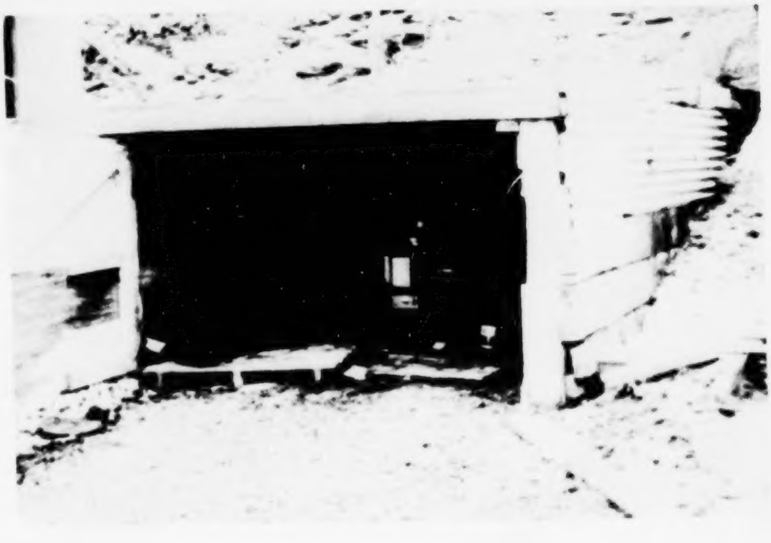

132
Stonerville
1600
1400
Middle Ridge Cem
Run
Mines
T
×1793
1700
1500

KING NO. 2 DEEP MINE PLOT PLAN

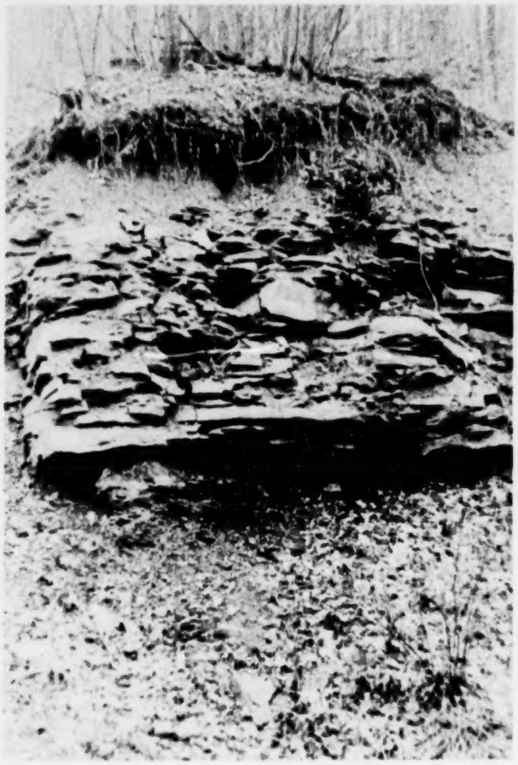
FIGURE 10



KING NO. 2 MINE SITE SHOWING LOCATION OF TRAILER AND MINE PORTAL USED FOR AIR INJECTION - DECEMBER, 1968
FIGURE 11



MAIN PORTAL OF KING NO. 2 MINE SHOWING ENGINE AND BLOWER ASSEMBLY - DECEMBER, 1968
FIGURE 12



TYPICAL FRACTURED OVERBURDEN
AT KING NO. 2 MINE SITE
FIGURE 13

mine with concrete block seals. Two air seals were installed in the lower entries and solid concrete block seals were installed in the three upper entries. All seals are still intact and the two air seals have a combined average flow of 1.6 liters per second (25 gpm) in the summer months and approximately 0.3 to 0.6 liters per second (5 to 10 gpm) throughout the winter. This discharge enters Cucumber Run approximately 1.6 kilometers (1 mile) above Cucumber Falls. Tables 2 and 3 are analyses of the King No. 2 mine discharge and Cucumber Run at a point below the King and Whipkey mine discharges.

TABLE 2
WATER QUALITY ANALYSES
KING MINE DISCHARGE

Date	12/31/68	1/6/70	2/25/70	1/28/71	5/26/71
Flow (gpm)	-	10	10	10	10
M. O. Alkalinity ($CaCO_3$)	0	0	0	0	-
Total Acidity ($CaCO_3$)	2464	988	850	1220	788
Conductivity (25°C) mmhos	-	-	-	-	2400
pH (Electrometrically)	2.4	2.6	2.6	2.5	2.6
Calcium (Ca)	53.6	-	-	112	86
Magnesium (Mg)	20.8	-	-	30	92
Total Hardness ($CaCO_3$)	221	500	850	530	600
Sulfate (SO_4)	3505	1323	984	1200	1140
Ferrous Iron (Fe)	524	26	25	188	140
Total Iron (Fe)	713	52	52	240	36
Aluminum (Al)	63	-	33	48	-
Manganese (Mn)	-	-	1.8	1.9	-

TABLE 3
WATER QUALITY ANALYSES
CUCUMBER RUN BELOW WHIPKEY AND KING NO. 2 MINE DISCHARGES

Date	8/4/69	1/6/70	2/25/70	1/28/71	5/26/71
Flow (gpm)	1125	2250	2000	1350	1350
M. O. Alkalinity ($CaCO_3$)	<1	2	4	0	-
Total Acidity ($CaCO_3$)	8	4	4	10	8
Conductivity (25°C) mmhos	-	-	-	-	108
pH (Electrometrically)	5.2	4.4	4.5	4.2	4.1
Calcium (Ca)	6.4	-	-	6.4	5.6
Magnesium (Mg)	3.8	-	-	3.8	0.24
Total Hardness ($CaCO_3$)	32	26	52	32	24
Sulfate (SO_4)	18	19	22	36	28
Ferrous Iron (Fe)	-	0.16	0.17	0.99	0.58
Total Iron (Fe)	1.4	1.1	0.62	1.0	1.4
Aluminum (Al)	-	-	0.49	0.60	0.91
Manganese (Mn)	0.2	-	0.13	0.16	-

SECTION V
SYSTEM PARAMETERS AND ENGINEERING CALCULATIONS

The Whipkey deep mine was originally selected as the site for the first phase of the overall project. The purpose of this phase was to determine the volume of gas that must be pumped into a mine to maintain a slight positive pressure over barometric conditions at all times. Such a pressure would insure against a mine "inhaling" which occurs when the barometric pressure is rising, or is at a "high."

Based upon preliminary calculations, it was decided to construct dry seals in the upper openings to the mine and inject air with a positive-displacement blower driven by an air-cooled, gasoline engine. Air flow into the mine from the blower was measured by a laminar flow metering system; ambient pressure with a very sensitive and accurate barometer; mine pressure by an electronic differential pressure system. Ambient and mine temperature were also measured. The entire system was operated on 110 volt A.C. current generated by a 12 volt alternator attached to the gasoline engine. All measurements were recorded on strip chart recorders. The entire system was designed to be as mobile as possible and therefore, as much of the instrumentation as possible was mounted in a trailer.

In order to determine the range of air blowing rates to be used during this study, both the free-breathing rate of the mine and the air flow required to create a slight differential pressure were calculated.

Free-Breathing Rate

Coal was known to have been removed from the Whipkey mine to the extent of approximately 50 acres. The mine had a working height of 42 inches and the estimated coal removal was 60%. The abandoned mine, if completely open, with little roof collapse, would have a void volume of:

$$20 \text{ hectares} \times 10{,}000 \text{ m}^2/\text{hectare} \times 1.07 \text{ m} \times 60\% =$$

$$129{,}000 \text{ cubic meters or } 4.57 \times 10^6 \text{ cubic feet}$$

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To determine the free-breathing rate, it is known that there are typical barometric high's and low's of 77.47 centimeter (30.50") Hg and 75.82 centimeters (29.85") Hg, respectively in western Pennsylvania. During adverse conditions, a complete change from a high to a low might occur within a 48 hour period. A maximum rate of change could be as much as 0.5 centimeters (0.2") Hg in a 3 hour period. Using this information, the maximum free-breathing rate was calculated for the unsealed Whipkey mine by Boyle's Law.

$$
\begin{aligned}
P_1V_1 &= P_2V_2 \\
V_2 &= P_1V_1/P_2 \\
&= 1.30 \times 10^5 \ (75.82/76.33) \\
&= 1.29 \times 10^5 \text{ cubic meters or } 4.55 \text{ cubic feet}
\end{aligned}
$$

A volume change of 32,000 cubic feet of air could be expected to enter or leave the mine (depending upon rising or falling barometric pressure) under the adverse conditions of a 0.5 centimeter (0.2") Hg change over a three (3) hour period. To overcome this free-breathing, a minimum air injection rate of 5.1 centimeters/minute (180 cfm) would be required.

Mine Pressurization Requirements

In order to develop a slight pressure within the mine, all sizeable openings and fissures would have to be sealed and air injected at a rate that would overcome any air flow into the mine from the atmosphere, especially during periods of rising barometric pressure. The air flow rate (Q) required to develop a slight, but positive pressure of 0.64 centimeters (0.25") H_2O was estimated by the equation:

$$P_a - P_b = (G^2/g_c c\bar{\rho}) \ (2fL_e/D_e)$$

where

P_a = final pressure = 75.82 cm Hg = 1030.8 cm H_2O = 10,308.3 kg - force/m^2

P_b = inlet pressure required = 1030.8 cm + 0.64 cm = 1031.44 cm H_2O = 10314 kg - force/m^2

G_2 = $(w/s)^2$

w = mass flow rate, kg/sec

s = cross-sectional area = 3.05 m x 1.07 m = 3.25 m^2

g_c = gravitational constant = 4.45 kg - m/kg - force sec^2/lb-force-sec^2

L_e = equivalent length = 129,422 cu. m/3.22 m^2 = 40,193 m

D_e = equivalent diameter = 1.58 m from hydraulic radius

$\bar{\rho}$ = average density of air = 1.29 kg/m^3 at 70°

f = friction factor, assumed = 0.1 minimum

In using this equation to determine the mass flow rate w, the following assumptions were made:

a. The volume of the mine was converted to one continuous passageway: 40,193 m x 3.05 m x 1.07 m

b. The air flow through the passageway is adiabatic.

c. A residual pressure of 0.64 cm H_2O must be added to the barometric pressure to determine the required inlet pressure.

$$w = \frac{(P_a-P_b)\, g_c\, D_e s^2}{2\, f\, L_e} \quad 1/2$$

$$= 0.394 \text{ kg/sec}$$

$$Q = 0.394 \text{ kg/sec} = 18.41 \text{ cu. m/minute}$$

These calculations indicated that a gas injected at the rate of 18.41 cu. m/minute (650 cfm) should be sufficient to create a slight positive pressure of approximately 0.64 cm H_2O.

SECTION VI
EQUIPMENT DESIGN

After selection of the field site for the demonstration project was completed, the acquisition of the field equipment began. It was decided to mount all recording and monitoring equipment in a trailer and a 16 foot model was selected. The trailer was outfitted with living equipment (cot, and gas operated heater, stove and refrigerator) in order that the field personnel could remain at the site for 24 hour periods or longer. A schematic showing the trailer equipment arrangement appears in Figure 14 and photographs of the trailer and its inside in Figures 15 and 16, respectively.

The power supply to operate the electrical transmitting monitors originated from a 12 volt alternator on the gasoline engine used to drive the blower. This D.C. current was converted to 110 volt A.C. by an invertor. In addition, a 16 hour emergency power supply was maintained by use of eight 12-volt storage batteries.

This portion of the demonstration project functioned around the use of a 3 lobe, rotary, positive displacement blower manufactured by the M-D Division of MGD Pneumatics, Inc. The blower was a light duty unit, Model 11-5509 capable of producing a maximum pressure of 10 psi at 3600 rpm.

The blower was driven by an Onan Model CCK industrial engine. This gasoline engine is a two cylinder, two cycle unit capable of producing 12.9 horsepower at 2700 rpm. The engine was coupled to the blower by a 5-1/2" diameter direct mounted Rockford clutch. A photograph of the engine-blower assembly is shown in Figure 17 and arrangement of the equipment at both the Whipkey and King No. 2 mines in Figures 18 and 19, respectively.

The air flow rate from the blower into the mine was measured by a laminar flow metering system manufactured by the Meriam Instrument Company, Model 50MC2-4P. This system was capable of measuring 400 cfm at 8" H_2O. The unit converted turbulent air flow to laminar flow and measured differential pressure on a Meriam Model 40HE35 WM Inclined Tube Manometer which has a 40" scale length with graduations of 0.01".

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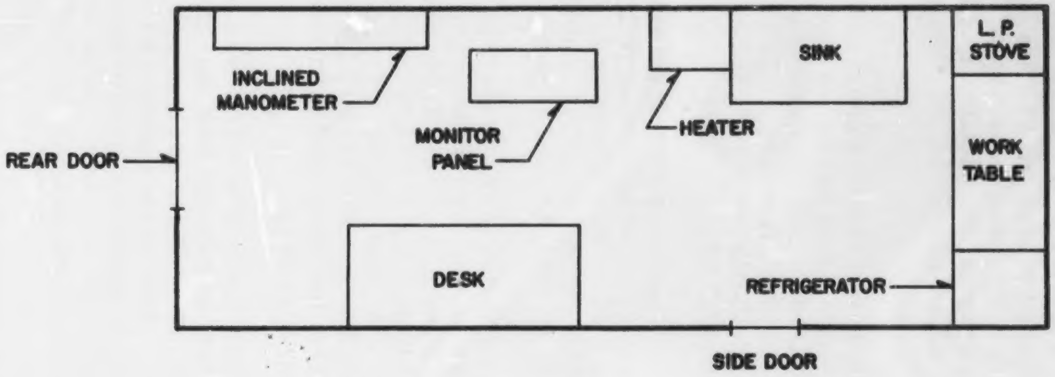
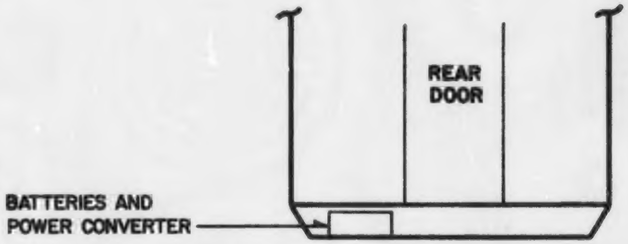

INCLINED MANOMETER
MONITOR PANEL
HEATER
SINK
L.P. STOVE
WORK TABLE
REAR DOOR
DESK
REFRIGERATOR
SIDE DOOR

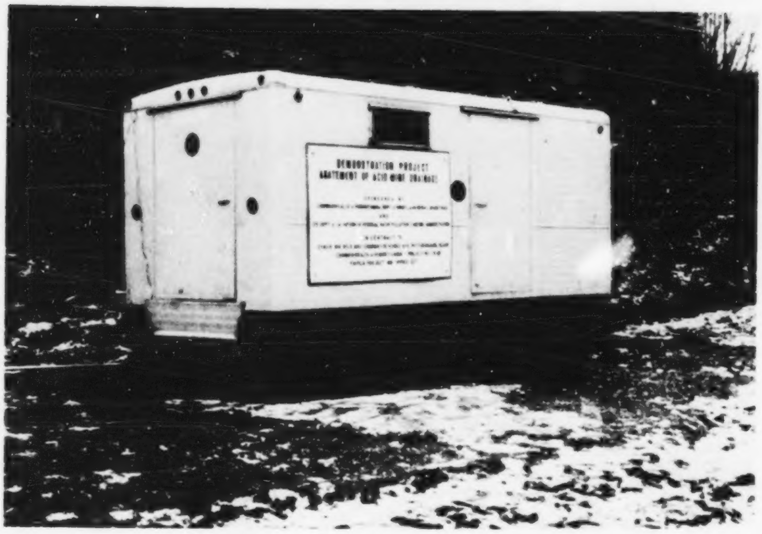
FLOOR PLAN


REAR DOOR
BATTERIES AND POWER CONVERTER

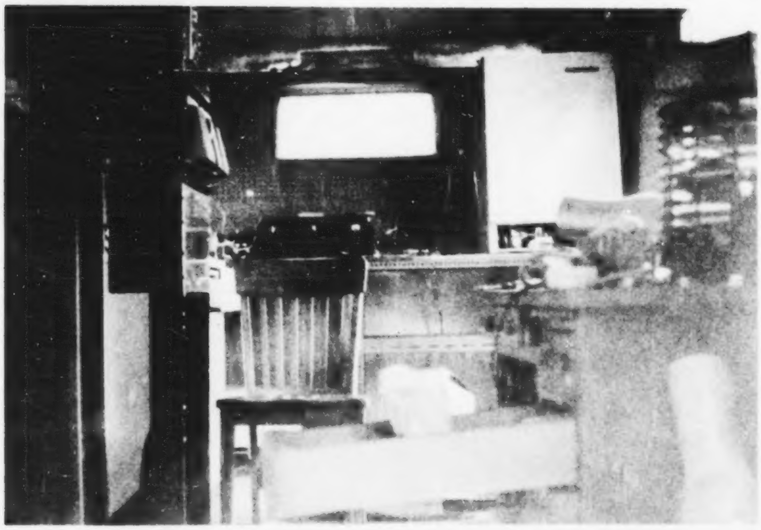
REAR VIEW

TRAILER EQUIPMENT LAYOUT

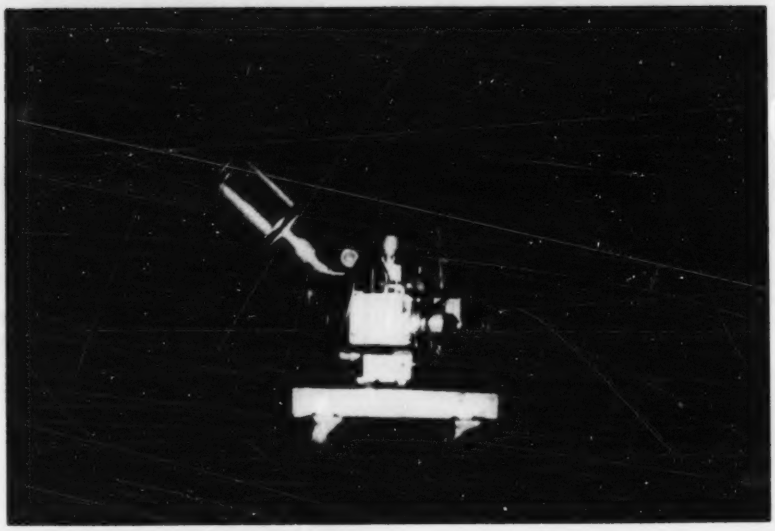
FIGURE 14


DEMONSTRATION PROJECT
ABATEMENT OF ACID MINE DRAINAGE

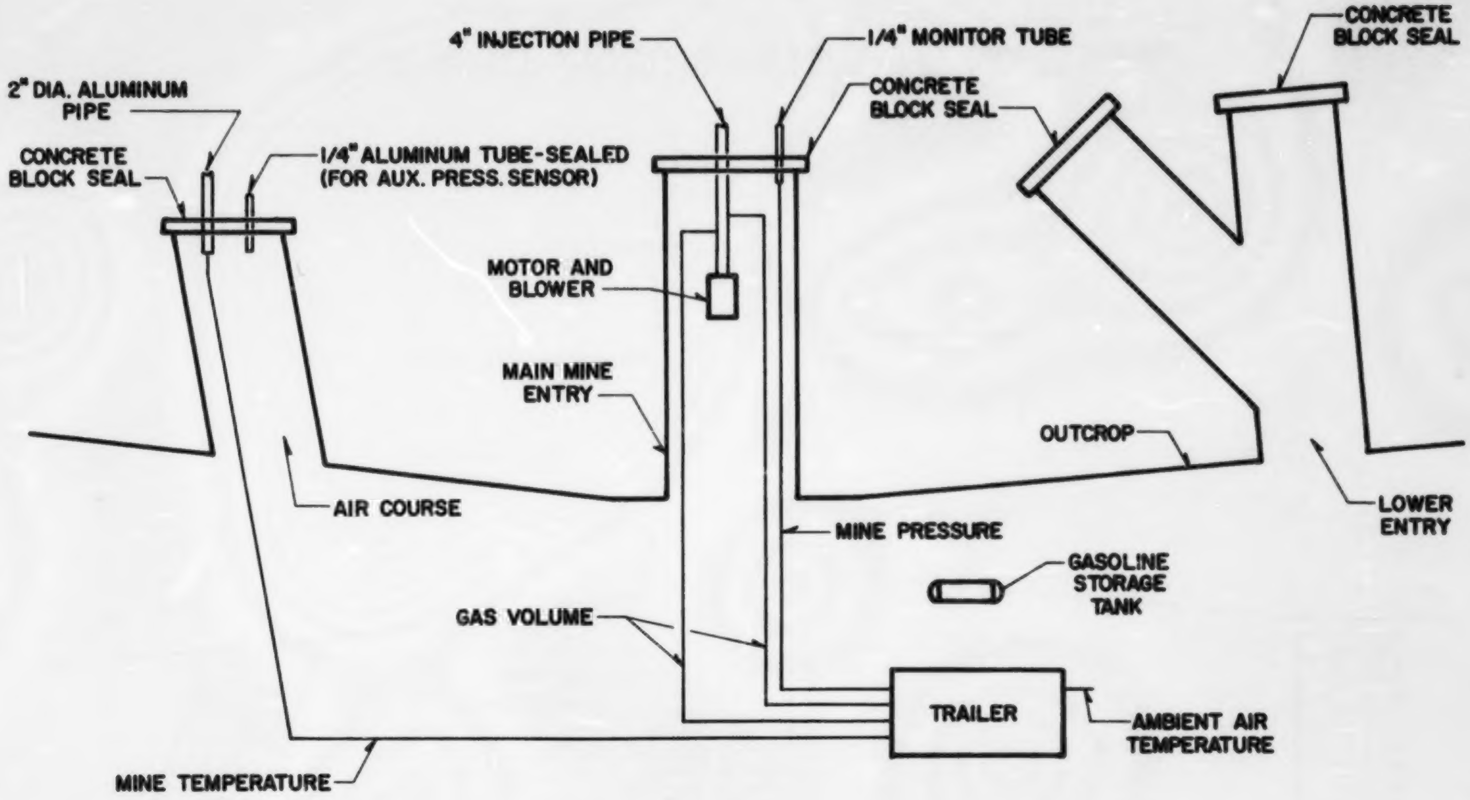
TRAILER SHOWN AT KING NO. 2 MINE SITE
DECEMBER, 1968
FIGURE 15



INSIDE OF TRAILER SHOWING INSTRUMENT PANEL IN FOREGROUND
AUGUST, 1968
FIGURE 16

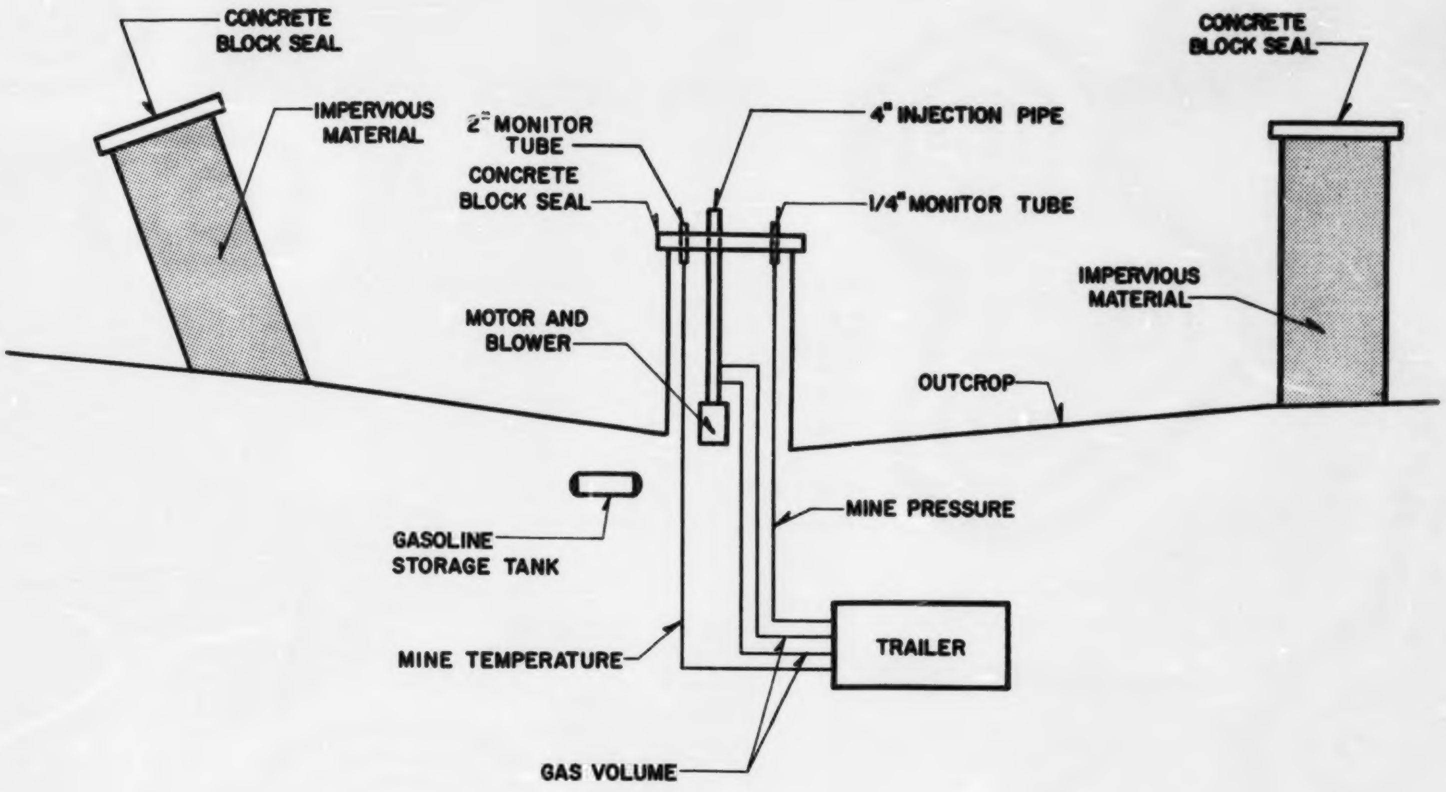


ENGINE AND BLOWER ASSEMBLY INSIDE MAIN PORTAL
CONCRETE SEAL IS 10 FEET IN BACKGROUND
AUGUST, 1968
FIGURE 17


2" DIA. ALUMINUM PIPE
CONCRETE BLOCK SEAL
1/4" ALUMINUM TUBE-SEALED (FOR AUX. PRESS. SENSOR)
4" INJECTION PIPE
1/4" MONITOR TUBE
CONCRETE BLOCK SEAL
CONCRETE BLOCK SEAL
MOTOR AND BLOWER
MAIN MINE ENTRY
OUTCROP
AIR COURSE
LOWER ENTRY
MINE PRESSURE
GASOLINE STORAGE TANK
GAS VOLUME
TRAILER
AMBIENT AIR TEMPERATURE
MINE TEMPERATURE

EQUIPMENT ARRANGEMENT (WHIPKEY DEEP MINE)

FIGURE 18


CONCRETE BLOCK SEAL
IMPERVIOUS MATERIAL
2" MONITOR TUBE
CONCRETE BLOCK SEAL
4" INJECTION PIPE
1/4" MONITOR TUBE
CONCRETE BLOCK SEAL
IMPERVIOUS MATERIAL
MOTOR AND BLOWER
OUTCROP
MINE PRESSURE
GASOLINE STORAGE TANK
TRAILER
MINE TEMPERATURE
GAS VOLUME

EQUIPMENT ARRANGEMENT (KING NO. 2 MINE)

FIGURE 19

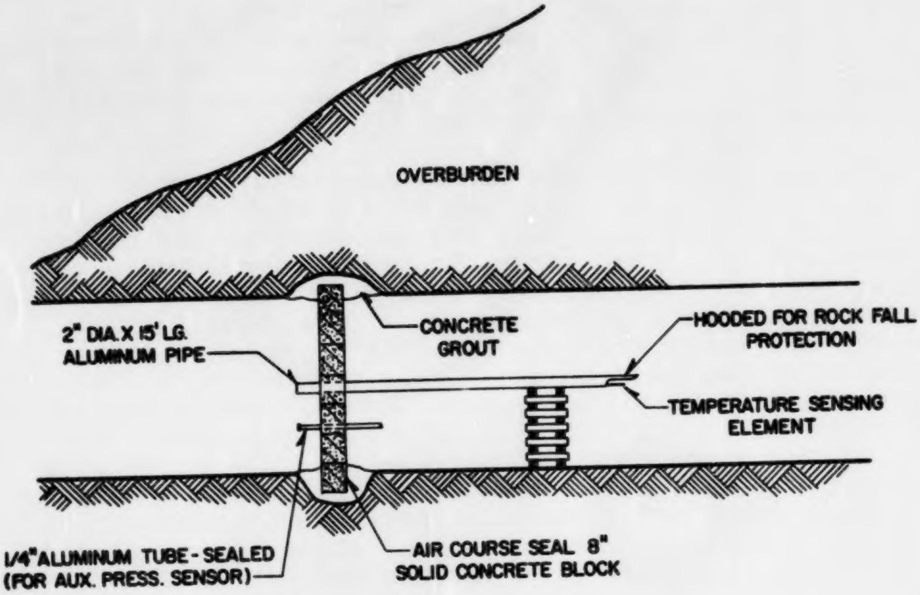
Also provided was a Meriam Model 30EB25 WM well type manometer. This unit measured the upstream air flow pressure including mine pressure, line pressure drop, and flow cell differential pressure to indicate the density of the gas. This, in turn, was used to determine the volume of gas being injected into the mine. This manometer has a 20" scale length with graduations of 0.1".

The differential pressures were recorded on a Model 6400H automatic recorder manufactured by the Foxboro Company. Two such recorders were used for this study, one having two pens and the other three, in order to provide a continuous record of ambient and mine temperatures, differential mine and gas flow pressures, and ambient humidity. Pressure differentials were transmitted to the automatic recorders by two Fischer and Porter Company Model 10B2494AA Electronic Differential Pressure Transmitters which operated in a range of 0" - 2" or 0" - 20" water pressure. The principle of operation of this instrument is the difference between two pressures is sensed by a measuring diaphragm which converts the differential pressure into an output current. A typical installation of the temperature and differential pressure cells through the mine seals is shown in Figure 20.

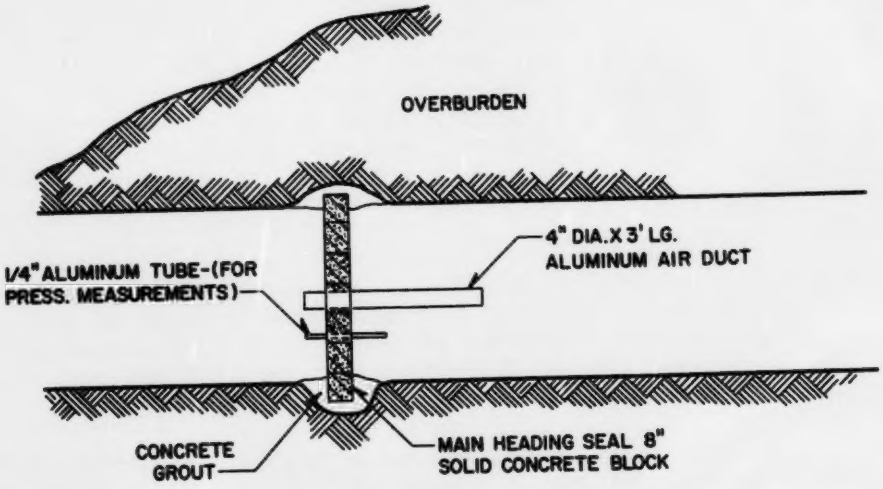
The differential pressure cell was coupled in parallel with a Model 66 K Integrator and Model N 129YK Kessler-Ellis Six Digit Manual Reset Totalizing Impulse Counter. The integrator converts the output current from the differential pressure cell to a pulse rate output which is used to actuate the electromechanical count of the total gas volume pumped into the mine over an extended period. A schematic of the instrumentation system is shown in Figure 21 and a photograph of this instrument panel in Figure 22.

An Electric Controller, Model 854, was purchased from the Hays Corporation to precisely regulate the volume of air pumped into the mine; however, it was later discovered that the engine throttle afforded sufficient regulation and the controller was not used.

Barometric changes were recorded on a Taylor Cyclo-Stormograph. This barometer has a range of 3.0" Hg with graduations of 0.1" which are readable to 0.01".


OVERBURDEN
2" DIA. X 15' LG. ALUMINUM PIPE
CONCRETE GROUT
HOODED FOR ROCK FALL PROTECTION
TEMPERATURE SENSING ELEMENT
1/4" ALUMINUM TUBE - SEALED (FOR AUX. PRESS. SENSOR)
AIR COURSE SEAL 8" SOLID CONCRETE BLOCK

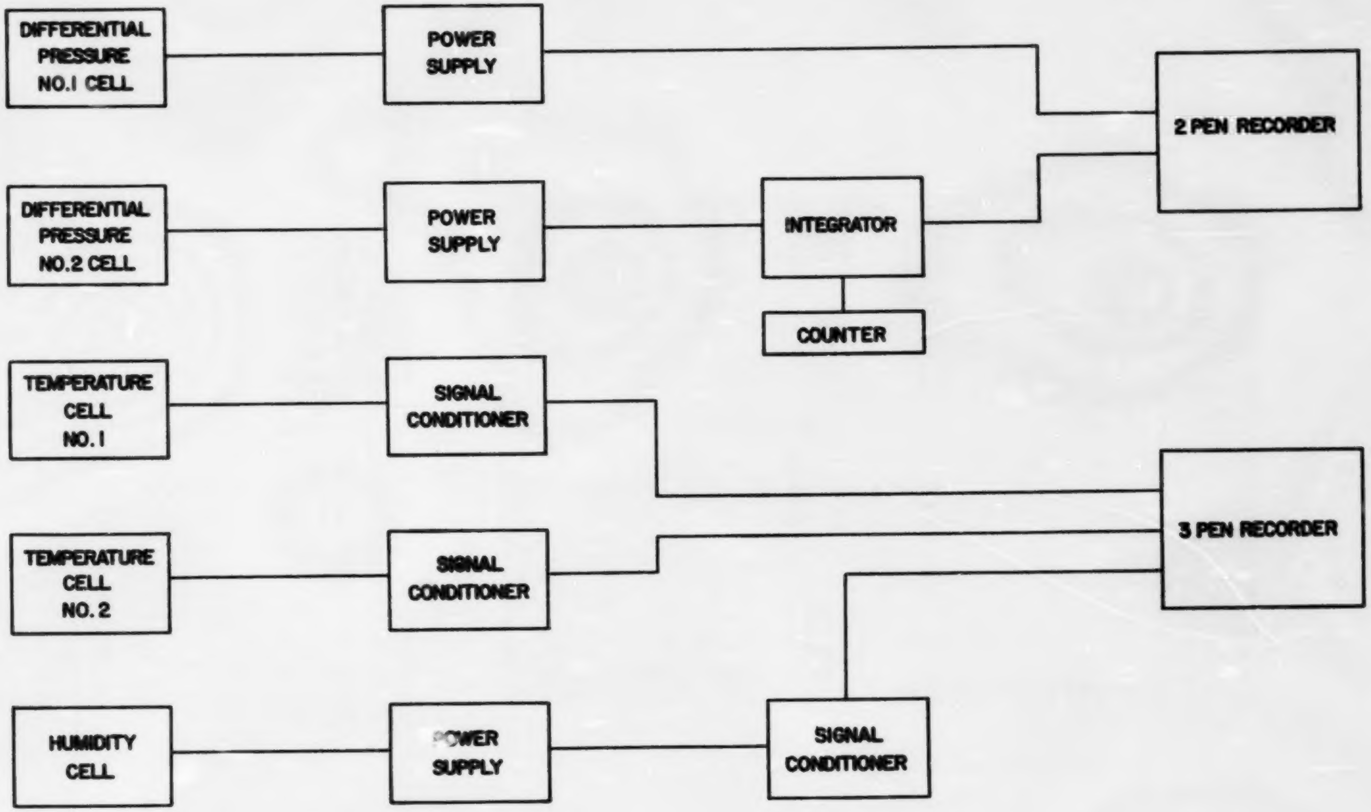
AIR COURSE SEAL


OVERBURDEN
4" DIA. X 3' LG. ALUMINUM AIR DUCT
1/4" ALUMINUM TUBE - (FOR PRESS. MEASUREMENTS)
CONCRETE GROUT
MAIN HEADING SEAL 8" SOLID CONCRETE BLOCK

MAIN HEADING SEAL

INSTALLATION OF MONITOR CELLS (WHIPKEY MINE)

FIGURE 20


DIFFERENTIAL PRESSURE NO.1 CELL
POWER SUPPLY
2 PEN RECORDER
DIFFERENTIAL PRESSURE NO.2 CELL
POWER SUPPLY
INTEGRATOR
COUNTER
TEMPERATURE CELL NO.1
SIGNAL CONDITIONER
3 PEN RECORDER
TEMPERATURE CELL NO.2
SIGNAL CONDITIONER
HUMIDITY CELL
POWER SUPPLY
SIGNAL CONDITIONER

INSTRUMENTATION FLOW DIAGRAM

FIGURE 21

INSTRUMENT PANEL CONTAINING DIFFERENTIAL PRESSURE
INDICATING RECORDING EQUIPMENT
INCLINED MANOMETER IN BACKGROUND
AUGUST, 1968
FIGURE 22

SECTION VII
PROJECT OPERATION AND RESULTS

Whipkey Mine

On August 22, 1968, the final calibration of all instruments essential to the initial start-up of the project was completed. During the field calibration, it was found that the Dewcel and also the integrator-counter which records the volume of air blown into the mine, were faulty and these were returned for replacement or repair. The motor and air pumping equipment were started and initial air flow was set at 10.5 cu. m/minute (375 cfm).

After one week of continuous pumping, it was apparent that a differential pressure was not building-up within the mine. It was then found that the mine pressure recording instrument which had been set to measure pressure in inches of water, was calibrated for too wide a range. This unit was recalibrated to record pressure in hundredths of an inch of water. In addition to this, an inclined manometer was fabricated to very accurately measure mine pressure as both a standby unit and a method of determining proper instrument calibration.

The operation of the air pumping equipment was interrupted for approximately one week due to difficulties in engaging the clutch.

In the interim, mine pressure versus atmospheric pressure was closely observed on the fabricated inclined manometer. After several barometric pressure cycles, it was evident that a very slight differential pressure was exerted during atmospheric pressure drops. Although the mine seals were apparently affording some restraint during periods of mine exhaling, the mine was still basically open and free-breathing.

With the aid of a former operator of the mine, a large opening into the mine was located on September 6, 1968. This was at one time an air course for the mine and when the strip mine was backfilled the air course was covered over by several feet of rocky soil. It had since eroded and caved in to the point that tunnel supports were visible. Flow measurements were taken at this old air course while pumping air into the mine. It was determined that the amount of air being expelled from this opening corresponded very closely to the amount of air being pumped into the mine. The tunnel was reopened, all debris removed, and then resealed on September 10th, with approximately 10 feet of impervious material.

Approximately one hour after construction of the seal had been completed, it was noted that a slight positive differential pressure was being recorded for the first time. Air flow into the mine at that time was approximately 420 cfm. This pumping rate was maintained for approximately one week. The results obtained appear in Table 4 in the Appendix. Although a trend did not establish at that time, differential mine pressure seemed to increase as atmospheric pressure decreased and vice versa. Mine pressure dropped to zero at the slightest barometric pressure increase. This problem pointed to the presence of either unlocated openings in the mine of significant size or many small openings of smaller dimension. It was obvious that these openings must be located and sealed, in order to build-up the differential pressures needed to calculate the air blowing requirements for injection of inert gases into mines of various sizes.

The first attempt to locate the leaks was merely to operate the blower at a flow rate of 500 cfm while the entire strip area was walked. There were no obvious areas where drafts or gas outflow was observed. At this point, it was suggested to make chemical smoke by injecting titanium tetrachloride into the mine through the air blower facilities. Approximately eight 1-pint bottles of titanium chloride were added to the mine over a period of about one hour on September 20, 1968. It was hoped that the titanium chloride would hydrolyze to titanium dioxide smoke. During and immediately after this chemical was added, the only obvious areas where smoke could be seen exiting from the mine were seepages near the mine seals. It was judged that these seepages were insufficient to account for the inability of the mine to hold air.

It was thought that better results would be achieved if a large quantity of titanium tetrachloride were added over a longer period of time to thoroughly blanket the mine with smoke. Accordingly, on October 4, five gallons of titanium tetrachloride liquid were added to the mine with the blower running. This had approximately the same results as with the previous 8-pint batch. Subsequently, it was decided

TABLE 4

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) RECORDED IN INCHES H_2O AT AIR FLOW RATE OF 420 CFM INTO THE WHIPKEY MINE FOR 144-HOUR PERIOD, SEPTEMBER 10-16, 1968

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
9/10/68	12:00 N	0.00	30.15
	2:00 P.M.	0.03	"
	4:00 P.M.	0.06	"
	6:00 P.M.	0.07	"
	8:00 P.M.	0.05	"
	10:00 P.M.	0.03	"
9/11/68	12:00 M	0.03	"
	2:00 A.M.	0.01	"
	4:00 A.M.	0.01	"
	6:00 A.M.	0.00	"
	8:00 A.M.	0.00	"
	10:00 A.M.	0.00	"
	12:00 N	0.00	30.14
	2:00 P.M.	0.00	30.14
	4:00 P.M.	0.00	30.13
	6:00 P.M.	0.00	30.13
	8:00 P.M.	0.01	30.12
	10:00 P.M.	0.01	30.12
9/12/68	12:00 M	0.01	30.11
	2:00 A.M.	0.00	30.11
	4:00 A.M.	0.00	30.10
	6:00 A.M.	0.00	30.10
	8:00 A.M.	0.00	30.09
	10:00 A.M.	0.00	30.09
	12:00 N	0.00	30.06
	2:00 P.M.	0.04	30.05
	4:00 P.M.	0.08	30.04
	6:00 P.M.	0.12	30.04
	8:00 P.M.	0.08	30.03
	10:00 P.M.	0.04	30.03
9/13/68	12:00 M	0.02	30.03
	2:00 A.M.	0.00	30.03
	4:00 A.M.	0.00	30.04
	6:00 A.M.	0.06	30.06
	8:00 A.M.	0.00	30.09
	10:00 A.M.	0.00	30.12
	12:00 N	0.06	30.13
	2:00 P.M.	0.08	30.13
	4:00 P.M.	0.12	30.16
	6:00 P.M.	0.14	30.18
	8:00 P.M.	0.12	30.20
	10:00 P.M.	0.10	30.22

TABLE 4 (continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
9/14/68	12:00 M	0.06	30.22
	2:00 A.M.	0.04	30.22
	4:00 A.M.	0.02	30.22
	6:00 A.M.	0.00	30.22
	8:00 A.M.	0.00	30.22
	10:00 A.M.	0.06	30.22
	12:00 N	0.10	30.21
	2:00 P.M.	0.14	30.19
	4:00 P.M.	0.16	30.17
	6:00 P.M.	0.10	30.17
	8:00 P.M.	0.16	30.17
	10:00 P.M.	0.12	30.16
9/15/68	12:00 M	0.06	30.15
	2:00 A.M.	0.00	30.13
	4:00 A.M.	0.00	30.10
	6:00 A.M.	0.00	30.08
	8:00 A.M.	0.00	30.08
	10:00 A.M.	0.00	30.08
	12:00 N	0.00	30.08
	2:00 P.M.	0.02	30.08
	4:00 P.M.	0.04	30.08
	6:00 P.M.	0.08	30.08
	8:00 P.M.	0.14	30.09
	10:00 P.M.	0.18	30.09
9/16/68	12:00 M	0.18	30.10
	2:00 A.M.	0.18	30.13
	4:00 A.M.	0.14	30.15
	6:00 A.M.	0.10	30.15
	8:00 A.M.	0.06	30.15
	10:00 A.M.	0.04	30.15
	12:00 N	0.04	30.15

to vaporize, or distill titanium tetrachloride into the mine with the blower running, hoping to disperse this chemical throughout the mine and have it convert in the mine to titanium dioxide smoke. This was to be done during a period when the climatic conditions were relatively dry with clear weather, and when the barometer was either ascending to a high or just after descending from a high.

Prior to distilling the titanium tetrachloride into the mine, two pints of oil of Wintergreen were pumped into the mine via the blower, with hopes that odors would aid in the location of any mine leaks. Other odor producing chemicals were considered such as chloropicrin, a strong lachrymator, or mercaptans which have been used to detect leaks in gas pipeline systems. It was concluded that the use of such indicators could have noxious or objectionable consequences to the surrounding area, especially if such indicators were to dissolve in the water exiting from the mine. It was, therefore, decided to use a more pleasant smelling scent such as oil of Wintergreen. The oil of Wintergreen was pumped into the mine over a 24-hour period and the overlying area was then extensively searched. Although a slight odor was believed to have been detected along the strip area, it could not be pinpointed nor was it detectable at the same point later in the day. In the mine air course, where small leaks had been discovered by titanium dioxide smoke, there was a definite odor of oil of Wintergreen; however, this odor was so weak that it is doubtful that it could be recognized in an open, windy environment.

Two subsequent attempts to locate the mine leaks by the vaporization of titanium tetrachloride were unsuccessful. It is believed that, in the extensive and convoluted passageways of the mine, the titanium dioxide smoke could have condensed on the moist tunnel walls before it could be adequately dispersed throughout the mine. It is also possible that the volume of smoke produced from this vaporization was insufficient to totally blanket the mine to the concentration required in order to see this smoke being emitted. Another possibility is that the porosity of the strip area backfill material was too great to permit any substantial buildup of pressure in the mine and the volume of indicating smoke was insignificant over this very large area. It is also conceivable that room collapse could have occurred in the mine, thus preventing the chemical smoke from escaping to the atmosphere. The data collected during this period is presented in Table 5.

A final attempt was made to develop a differential pressure within the Whipkey mine during the period November 1 to 5, 1968. Air was blown into the mine at a constant rate of 14 cu. m/minute (500 cfm) and small differential pressures were developed only during a "fall" in the barometric pressure. This differential was not maintained, but would dissipate within a few hours during steady ambient pressure indicating that the mine was free-breathing. The data obtained is tabulated in Table 6.

Because of the negative results obtained during the week of November 1, 1968, a joint meeting was held with representatives of the former Pennsylvania Coal Research Board, Federal Water Pollution Control Administration and Cyrus Wm. Rice and Company. It was jointly agreed that additional efforts at the Whipkey mine would be futile, but further work should continue. Attempts would be made to locate the sources of air leakage from the Whipkey mine by excavating areas in the strip mine where earlier entries into the mine existed. At the same time, the project equipment would be moved to the nearby King No. 2 mint on Cucumber Run which had previously been sealed as described in Section IV - Demonstration Mines, King No. 2 Mine. Air injection into the King No. 2 mine was to continue, as long as weather permitted or until the project funds expired.

King No. 2 Mine

The site and road preparation work was completed by November 21, 1968, and the trailer, engine-blower assembly and other necessary equipment were moved to the King No. 2 mine on that date. Instrument connections, however, were not completed for several days, and the engine and blower were finally put into operation on November 27, at a pumping rate of approximately 11.2 cu. m/minute (400 cfm). A slight mine pressure was apparent after several hours of pumping. This was encouraging since this was the first time that a positive pressure had been recorded during a barometric pressure rise.

TABLE 5

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) RECORDED IN INCHES H_2O AT VARYING AIR FLOW RATES DURING 76-HOUR PERIOD, SEPTEMBER 23-26, 1968 WHIPKEY MINE

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
9/23/68	12:00 N	0.00	30.37	375 CFM
	2:00 P.M.	0.09	30.33	"
	4:00 P.M.	0.08	30.32	"
	6:00 P.M.	0.09	30.32	"
	8:00 P.M.	0.08	30.32	"
	10:00 P.M.	0.08	30.32	"
9/24/68	12:00 M	0.08	30.32	"
	2:00 A.M.	0.07	30.32	"
	4:00 A.M.	0.06	30.32	"
	6:00 A.M.	0.06	30.32	"
	8:00 A.M.	0.06	30.32	"
	10:00 A.M.	0.04	30.32	"
	12:00 N	0.02	30.30	"
	2:00 P.M.	0.10	30.25	"
	4:00 P.M.	0.15	30.23	"
	6:00 P.M.	0.14	30.22	"
	8:00 P.M.	0.09	30.22	"
	10:00 P.M.	0.04	30.22	"
9/25/68	12:00 M	0.02	30.22	"
	2:00 A.M.	0.00	30.22	"
	4:00 A.M.	0.00	30.22	000 CFM
	6:00 A.M.	0.00	30.22	"
	8:00 A.M.	0.00	30.22	"
	10:00 A.M.	0.00	30.27	"
	12:00 N	0.01	30.27	410 CFM
	2:00 P.M.	0.01	30.26	"
	4:00 P.M.	0.03	30.23	"
	6:00 P.M.	0.03	30.21	"
	8:00 P.M.	0.03	30.21	"
	10:00 P.M.	0.03	30.21	"
9/26/68	12:00 M	0.02	30.22	"
	2:00 A.M.	0.01	30.22	"
	4:00 A.M.	0.00	30.22	"
	6:00 A.M.	0.00	30.22	"
	8:00 A.M.	0.00	30.24	"
	10:00 A.M.	0.00	30.25	"
	12:00 N	0.00	30.25	"
	2:00 P.M.	0.00	30.25	"
	4:00 P.M.	0.00	30.24	

TABLE 6

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) RECORDED IN INCHES H_2O AT CONSTANT AIR FLOW RATE OF 500 CFM DURING 104-HOUR PERIOD, NOVEMBER 1-5, 1968, AT SLOWLY FALLING BAROMETRIC PRESSURE WHIPKEY MINE

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
11/01/68	10:00 A.M.	0.00	30.35
	12:00 N	0.02	30.35
	2:00 P.M.	0.08	30.32
	4:00 P.M.	0.08	30.31
	6:00 P.M.	0.06	30.30
	8:00 P.M.	0.03	30.30
	10:00 P.M.	0.00	30.30
11/02/68	12:00 M	0.00	30.30
	2:00 A.M.	0.00	30.30
	4:00 A.M.	0.00	30.30
	6:00 A.M.	0.00	30.30
	8:00 A.M.	0.00	30.30
	10:00 A.M.	0.00	30.30
	12:00 N	0.03	30.30
	2:00 P.M.	0.06	30.28
	4:00 P.M.	0.06	30.27
	6:00 P.M.	0.04	30.27
	8:00 P.M.	0.00	30.27
	10:00 P.M.	0.00	30.27
11/03/68	12:00 M	0.00	30.27
	2:00 A.M.	0.00	30.27
	4:00 A.M.	0.00	30.27
	6:00 A.M.	0.00	30.27
	8:00 A.M.	0.00	30.27
	10:00 A.M.	0.00	30.27
	12:00 N	0.00	30.27
	2:00 P.M.	0.00	30.27
	4:00 P.M.	0.00	30.27
	6:00 P.M.	0.00	30.27
	8:00 P.M.	0.00	30.27
	10:00 P.M.	0.00	30.27
11/04/68	12:00 M	0.00	30.27
	2:00 A.M.	0.00	30.27
	4:00 A.M.	0.00	30.27
	6:00 A.M.	0.00	30.27
	8:00 A.M.	0.00	30.27
	10:00 A.M.	0.00	30.27
	12:00 N	0.00	30.27
	2:00 P.M.	0.00	30.27
	4:00 P.M.	0.00	30.27
	6:00 P.M.	0.00	30.27
	8:00 P.M.	0.00	30.27
	10:00 P.M.	0.00	30.25

TABLE 6 (continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
11/05/68	12:00 M	0.00	30.25
	2:00 A.M.	0.00	30.20
	4:00 A.M.	0.00	30.20
	6:00 A.M.	0.00	30.20
	8:00 A.M.	0.00	30.16
	10:00 A.M.	0.00	30.18
	12:00 N	0.00	30.17
	2:00 P.M.	0.02	30.16
	4:00 P.M.	0.03	30.15
	6:00 P.M.	0.03	30.15

The blower was operated at this pumping rate for one week. Results at the end of the one week period were generally inconclusive. Although a positive mine pressure was recorded throughout most of this time, mine pressure frequently dropped to zero for brief periods and failed to follow any definite pattern in relationship to barometric pressure changes. The differential pressures recorded during this period are tabulated in Table 7.

In an attempt to establish some type of pattern, the flow instruments were disconnected so the pumping rate could be increased. The Meriam inclined manometer, formerly used for air flow determinations, was connected to mine pressure in order to obtain a more precise reading. The blower was put into operation at an estimated pumping rate of 16.1 cu. m/minute (575 cfm) on December 4, 1968. Mine pressure fluctuated for two hours and finally reached a relatively stable state at 0.13 cm (0.05") H_2O on the manometer. The blower was run overnight at a pumping rate of approximately 16.1 cu. m/minute (575 cfm) to determine what pressures could be maintained at this increased air flow. A slight differential pressure was recorded throughout the night [0.05 cm (0.02" H_2O)], during which time barometric pressure was rising.

At noon on December 5, the blower was shut-off to determine the time required for the mine pressure to return to atmospheric pressure. Differential pressure fell to zero within 30 seconds and then began to fluctuate on the manometer, sometime as high as 0.89 cm (0.35") H_2O. The weather conditions were snowy and extremely windy and the barometric pressure was just beginning to rise. The fluctuations appeared to be directly related to wind direction and velocity, and as the wind diminished, differential mine pressure also returned to zero. Although all indications are that the mine was relatively open and free-breathing, several extensive searches failed to locate any fractures or openings into the mine.

The air flow instruments were again connected and pumping was resumed at a rate of 12.6 cu. m/minute (450 cfm). A pumping rate of 11.9-13.7 cu. m/minute (425-490 cfm) was maintained during most of the period, December 5 through 12, 1968. At the end of this time, a definite pattern had still not been established. (See Table 7)

TABLE 7

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) RECORDED IN INCHES H_2O AT VARYING AIR FLOW RATES OVER A 16-DAY PERIOD, NOVEMBER 27 TO DECEMBER 14, 1968, DURING A COMPLETE BAROMETRIC CYCLE
KING NO. 2 MINE

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
11/27/68	2:00 P.M.	.05	30.41	400 CFM
	4:00 P.M.	.06	30.42	400 CFM
	6:00 P.M.	.02	30.42	425 CFM
	8:00 P.M.	.01	30.42	"
	10:00 P.M.	.00	30.42	"
11/28/68	12:00 M	.00	30.42	"
	2:00 A.M.	.00	30.40	"
	4:00 A.M.	.00	30.38	"
	6:00 A.M.	.00	30.35	"
	8:00 A.M.	.00	30.33	"
	10:00 A.M.	.00	30.31	"
	12:00 N	.01	30.22	"
	2:00 P.M.	.04	30.12	"
	4:00 P.M.	.05	30.08	"
	6:00 P.M.	.06	30.02	"
	8:00 P.M.	.05	30.00	"
	10:00 P.M.	.05	30.00	"
11/29/68	12:00 M	.05	30.02	"
	2:00 A.M.	.04	30.04	"
	4:00 A.M.	.03	30.08	"
	6:00 A.M.	.02	30.12	"
	8:00 A.M.	.01	30.18	"
	10:00 A.M.	.00	30.25	"
	12:00 N	.00	30.28	"
	2:00 P.M.	.00	30.36	"
	4:00 P.M.	.01	30.38	"
	6:00 P.M.	.00	30.41	"
	8:00 P.M.	.00	30.43	"
	10:00 P.M.	.00	30.44	"
11/30/68	12:00 M	.01	30.46	"
	2:00 A.M.	.00	30.48	"
	4:00 A.M.	.02	30.50	"
	6:00 A.M.	.02	30.51	"
	8:00 A.M.	.02	30.54	"
	10:00 A.M.	.02	30.57	"
	12:00 N	.01	30.59	"
	2:00 P.M.	.01	30.59	"
	4:00 P.M.	.01	30.59	"
	6:00 P.M.	.01	30.59	"
	8:00 P.M.	.02	30.60	"
	10:00 P.M.	.02	30.60	"

TABLE 7 (continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
12/01/68	12:00 M	.01	30.62	415 CFM
	2:00 A.M.	.02	30.61	"
	4:00 A.M.	.03	30.59	"
	6:00 A.M.	.03	30.56	"
	8:00 A.M.	.02	30.54	"
	10:00 A.M.	.02	30.52	"
	12:00 N	.02	30.50	"
	2:00 P.M.	.02	30.42	"
	4:00 P.M.	.01	30.35	"
	6:00 P.M.	.01	30.28	"
	8:00 P.M.	.01	30.28	"
	10:00 P.M.	.01	30.29	"
12/02/68	12:00 M	.01	30.30	"
	2:00 A.M.	.01	30.30	"
	4:00 A.M.	.01	30.30	"
	6:00 A.M.	.02	30.30	"
	8:00 A.M.	.01	30.31	"
	10:00 A.M.	.02	30.31	"
	12:00 N	.03	30.31	"
	2:00 P.M.	.02	30.32	"
	4:00 P.M.	.03	30.32	"
	6:00 P.M.	.02	30.32	"
	8:00 P.M.	.01	30.33	"
	10:00 P.M.	.01	30.33	"
12/03/68	12:00 M	.01	30.33	"
	2:00 A.M.	.00	30.34	"
	4:00 A.M.	.01	30.34	"
	6:00 A.M.	.01	30.34	"
	8:00 A.M.	.01	30.34	"
	10:00 A.M.	.00	30.33	"
	12:00 N	.00	30.33	"
	2:00 P.M.	.00	30.30	"
	4:00 P.M.	.00	30.25	"
	6:00 P.M.	.00	30.20	"
	8:00 P.M.	.00	30.17	"
	10:00 P.M.	.02	30.13	"
12/04/68	12:00 M	.02	30.04	"
	2:00 A.M.	.01	30.00	"
	4:00 A.M.	.01	29.95	"
	6:00 A.M.	.00	29.87	"
	8:00 A.M.	.01	29.83	"
	10:00 A.M.	.01	29.82	"
	12:00 N	.00	29.77	575 CFM
	2:00 P.M.	.00	29.78	"
	4:00 P.M.	.02	29.80	"
	6:00 P.M.	.02	29.84	"
	8:00 P.M.	.01	29.87	"
	10:00 P.M.	.01	29.88	"

TABLE 7 (continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
12/05/68	12:00 M	.02	29.89	575 CFM
	2:00 A.M.	.02	29.89	"
	4:00 A.M.	.01	29.88	"
	6:00 A.M.	.02	29.85	"
	8:00 A.M.	.01	29.82	"
	10:00 A.M.	.02	29.80	"
	12:00 N		29.85	000 CFM
	2:00 P.M.		29.87	000 CFM
	4:00 P.M.	.03	29.90	450 CFM
	6:00 P.M.	.01	29.94	"
	8:00 P.M.	.02	30.01	"
	10:00 P.M.	.03	30.08	"
12/06/68	12:00 M	.03	30.12	"
	2:00 A.M.	.02	30.14	"
	4:00 A.M.	.03	30.17	"
	6:00 A.M.	.02	30.18	"
	8:00 A.M.	.03	30.20	"
	10:00 A.M.	.03	30.25	"
	12:00 N	.07	30.30	325 CFM
	2:00 P.M.	.06	30.27	"
	4:00 P.M.	.05	30.28	"
	6:00 P.M.	.01	30.29	"
	8:00 P.M.	.00	30.30	"
	10:00 P.M.	.00	30.31	"
12/07/68	12:00 M	.00	30.31	"
	2:00 A.M.	.00	30.32	"
	4:00 A.M.	.00	30.32	"
	6:00 A.M.	.01	30.32	"
	8:00 A.M.	.00	30.32	"
	10:00 A.M.	.01	30.32	425 CFM
	12:00 N	.00	30.32	"
	2:00 P.M.	.00	30.32	"
	4:00 P.M.	.00	30.32	"
	6:00 P.M.	.00	30.32	"
	8:00 P.M.	.00	30.32	"
	10:00 P.M.	.00	30.32	"
12/08/68	12:00 M	.00	30.33	"
	2:00 A.M.	.00	30.33	"
	4:00 A.M.	.00	30.33	"
	6:00 A.M.	.00	30.33	"
	8:00 A.M.	.01	30.33	"
	10:00 A.M.	.00	30.35	"
	12:00 N	.00	30.43	"
	2:00 P.M.	.00	30.43	"
	4:00 P.M.	.00	30.47	"

TABLE 7 (continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
12/08/68	6:00 P.M.	.01	30.49	425 CFM
	8:00 P.M.	.01	30.51	"
	10:00 P.M.	.01	30.52	"
12/09/68	12:00 M	.00	30.52	"
	2:00 A.M.	.01	30.54	"
	4:00 A.M.	.01	30.57	"
	6:00 A.M.	.00	30.59	"
	8:00 A.M.	.01	30.60	"
	10:00 A.M.	.01	30.62	"
	12:00 N	.04	30.63	"
	2:00 P.M.	.06	30.62	000 CFM
	4:00 P.M.	.02	30.62	425 CFM
	6:00 P.M.	.01	30.63	"
	8:00 P.M.	.00	30.65	000 CFM
	10:00 P.M.	.00	30.66	"
12/10/68	12:00 M	.00	30.67	"
	2:00 A.M.	.00	30.68	"
	4:00 A.M.	.00	30.69	"
	6:00 A.M.	.00	30.70	"
	8:00 A.M.	.00	30.73	"
	10:00 A.M.	.00	30.78	"
	12:00 N	.00	30.76	"
	2:00 P.M.	.00	30.70	"
	4:00 P.M.	.00	30.70	490 CFM
	6:00 P.M.	.01	30.70	"
	8:00 P.M.	.03	30.70	"
	10:00 P.M.	.03	30.70	"
12/11/68	12:00 M	.02	30.70	"
	2:00 A.M.	.01	30.70	"
	4:00 A.M.	.01	30.70	"
	6:00 A.M.	.00	30.69	"
	8:00 A.M.	.00	30.69	"
	10:00 A.M.	Chart Stuck	30.68	"
	12:00 N	Chart Stuck	30.64	"
	2:00 P.M.	Chart Stuck	30.59	"
	4:00 P.M.	Chart Stuck	30.58	"
	6:00 P.M.	Chart Stuck	30.57	"
	8:00 P.M.	Chart Stuck	30.55	"
	10:00 P.M.	Chart Stuck	30.55	"
12/12/68	12:00 M	Chart Stuck	30.54	"
	2:00 A.M.	Chart Stuck	30.53	"
	4:00 A.M.	Chart Stuck	30.53	"
	6:00 A.M.	Chart Stuck	30.53	"
	8:00 A.M.	Chart Stuck	30.54	"
	10:00 A.M.	.08	30.53	"

TABLE 7 (continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
12/12/68	12:00 N	.05	30.48	490 CFM
	2:00 P.M.	.10	30.43	"
	4:00 P.M.	.10	30.42	"
	6:00 P.M.	.09	30.43	"
	8:00 P.M.	.05	30.45	"
	10:00 P.M.	.03	30.42	"
12/13/68	12:00 M	.02	30.38	"
	2:00 A.M.	.01	30.33	"
	4:00 A.M.	.01	30.32	"
	6:00 A.M.	.01	30.30	"
	8:00 A.M.	0.00	30.30	575 CFM
	10:00 A.M.	0.00	30.28	"
	12:00 N	0.01	30.27	"
	2:00 P.M.	0.03	30.22	"
	4:00 P.M.	0.03	30.20	425 CFM
	6:00 P.M.	0.03	30.21	"
	8:00 P.M.	0.02	30.21	"
	10:00 P.M.	0.02	30.21	"
12/14/68	12:00 M	0.00	30.21	"

On the assumption that the mine pressure recorder lacked the adequate sensitivity required to measure the very slight mine pressures being exerted, mine pressures were recorded from the Meriam inclined manometer at five minute intervals over an eleven hour period on December 12, 1968. A positive differential pressure was recorded for five continuous hours at a pumping rate of approximately 13.7 cu. m/minute (490 cfm). The blower was then shut-off to determine the effect on mine pressure. The differential pressure immediately dropped to zero and remained there until pumping resumed one hour later. A positive differential pressure was then recorded for the remainder of this run. This data is shown on Table 8.

In comparing recorded differential pressure with the differential pressure observed on the inclined manometer, it was apparent that, at the marginal pressures being exerted, recorded results were not reliable. It was decided, therefore, that a 24-hour surveillance should be kept on the inclined manometer with results recorded at frequent intervals. This was to be done during a barometric pressure cycle or front, however, difficulties with the motor interfered with the original plan of operation.

The motor was repaired on December 23 and the blower was started at an air flow of approximately 16.1 cu. m/minute (575 cfm). This air flow rate was maintained over a 20-hour period. Differential mine pressures were recorded from the inclined manometer at five minute intervals. A constant positive pressure was maintained over this period, which at times rose as high as 0.71 cm (0.28") H_2O. The average pressure during this time was approximately 0.30 cm (0.12") H_2O. The data collected during this test run is tabulated in Table 9 (see Appendix). The air flow rate was then decreased to 10.4 cu. m/minute (370 cfm) and operated at this rate for approximately two hours. Differential pressure during this time averaged 0.25 cm (0.10") H_2O and did not drop below 0.23 cm (0.09") H_2O. The pumping rate was again decreased. Air flow this time was set at approximately 9.1 cu. m/minute (325 cfm) and pumping continued at this rate for two hours. Although differential pressure became marginal at this air flow rate, a positive pressure was also maintained throughout the run (see Table 9).

TABLE 8

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) RECORDED IN INCHES H_2O FROM THE INCLINED MANOMETER AT 5 MINUTE INTERVALS DURING AN 11-HOUR PERIOD ON DECEMBER 12, 1968, WITH A CONSTANT AIR FLOW OF 490 CFM INTO THE KING NO. 2 MINE

Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
9:00 A.M.	0.03	30.53	490 CFM
9:05 A.M.	0.03	30.53	"
9:10 A.M.	0.03	30.53	"
9:15 A.M.	0.04	30.53	"
9:20 A.M.	0.05	30.53	"
9:25 A.M.	0.04	30.53	"
9:30 A.M.	0.04	30.53	"
9:35 A.M.	0.05	30.53	"
9:40 A.M.	0.05	30.53	"
9:45 A.M.	0.04	30.53	"
9:50 A.M.	0.03	30.53	"
9:55 A.M.	0.05	30.53	"
10:00 A.M.	0.04	30.53	"
10:05 A.M.	0.04	30.53	"
10:10 A.M.	0.04	30.53	"
10:15 A.M.	0.04	30.53	"
10:20 A.M.	0.04	30.52	"
10:25 A.M.	0.04	30.52	"
10:30 A.M.	0.04	30.52	"
10:35 A.M.	0.04	30.52	"
10:40 A.M.	0.04	30.52	"
10:45 A.M.	0.05	30.51	"
10:50 A.M.	0.03	30.51	"
10:55 A.M.	0.04	30.51	"
11:00 A.M.	0.04	30.51	"
11:05 A.M.	0.04	30.50	"
11:10 A.M.	0.04	30.50	"
11:15 A.M.	0.04	30.50	"
11:20 A.M.	0.04	30.49	"
11:25 A.M.	0.04	30.49	"
11:30 A.M.	0.04	30.49	"
11:35 A.M.	0.04	30.49	"
11:40 A.M.	0.04	30.48	"
11:45 A.M.	0.04	30.48	"
11:50 A.M.	0.04	30.48	"
11:55 A.M.	0.04	30.48	"
12:00 N	0.04	30.48	"
12:05 P.M.	0.04	30.47	"
12:10 P.M.	0.04	30.47	"
12:15 P.M.	0.04	30.47	"
12:20 P.M.	0.04	30.46	"
12:25 P.M.	0.04	30.46	"
12:30 P.M.	0.04	30.46	"

TABLE 8 (continued)

Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
12:35 P.M.	0.03	30.46	490 CFM
12:40 P.M.	0.03	30.46	"
12:45 P.M.	0.04	30.46	"
12:50 P.M.	0.03	30.46	"
12:55 P.M.	0.04	30.46	"
1:00 P.M.	0.04	30.45	"
1:05 P.M.	0.04	30.45	"
1:10 P.M.	0.04	30.45	"
1:15 P.M.	0.04	30.45	"
1:20 P.M.	0.04	30.45	"
1:25 P.M.	0.03	30.45	"
1:30 P.M.	0.04	30.44	"
1:35 P.M.	0.04	30.44	"
1:40 P.M.	0.05	30.44	"
1:45 P.M.	0.04	30.43	"
1:50 P.M.	0.04	30.43	"
1:55 P.M.	0.04	30.43	"
2:00 P.M.	0.03	30.43	"
2:05 P.M.	0.00	30.42	000 CFM
2:10 P.M.	0.00	30.42	"
2:15 P.M.	0.00	30.42	"
2:20 P.M.	0.00	30.42	"
2:25 P.M.	0.00	30.42	"
2:30 P.M.	0.00	30.41	"
2:35 P.M.	0.00	30.41	"
2:40 P.M.	0.00	30.41	"
2:45 P.M.	0.00	30.41	"
2:50 P.M.	0.00	30.41	"
2:55 P.M.	0.00	30.41	"
3:00 P.M.	0.00	30.41	"
3:05 P.M.	0.03	30.42	490 CFM
3:10 P.M.	0.03	30.42	"
3:15 P.M.	0.03	30.42	"
3:20 P.M.	0.03	30.42	"
3:25 P.M.	0.03	30.42	"
3:30 P.M.	0.03	30.42	"
3:35 P.M.	0.03	30.42	"
3:40 P.M.	0.03	30.42	"
3:45 P.M.	0.03	30.42	"
3:50 P.M.	0.03	30.42	"
3:55 P.M.	0.03	30.42	"
4:00 P.M.	0.03	30.42	"
4:05 P.M.	0.03	30.43	"
4:10 P.M.	0.03	30.43	"
4:15 P.M.	0.03	30.43	"
4:20 P.M.	0.03	30.43	"
4:25 P.M.	0.03	30.43	"
4:30 P.M.	0.03	30.43	"

TABLE 8 (continued)

Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
4:35 P.M.	0.03	30.43	490 CFM
4:40 P.M.	0.03	30.43	"
4:45 P.M.	0.03	30.43	"
4:50 P.M.	0.03	30.43	"
4:55 P.M.	0.03	30.43	"
5:00 P.M.	0.03	30.43	"
5:05 P.M.	0.03	30.43	"
5:10 P.M.	0.03	30.43	"
5:15 P.M.	0.03	30.43	"
5:20 P.M.	0.03	30.43	"
5:25 P.M.	0.03	30.43	"
5:30 P.M.	0.03	30.43	"
5:35 P.M.	0.03	30.44	"
5:40 P.M.	0.03	30.44	"
5:45 P.M.	0.03	30.44	"
5:50 P.M.	0.03	30.44	"
5:55 P.M.	0.03	30.44	"
6:00 P.M.	0.03	30.44	"
6:05 P.M.	0.03	30.44	"
6:10 P.M.	0.03	30.44	"
6:15 P.M.	0.03	30.44	"
6:20 P.M.	0.03	30.44	"
6:25 P.M.	0.03	30.44	"
6:30 P.M.	0.03	30.44	"
6:35 P.M.	0.03	30.44	"
6:40 P.M.	0.03	30.44	"
6:45 P.M.	0.03	30.45	"
6:50 P.M.	0.03	30.45	"
6:55 P.M.	0.03	30.45	"
7:00 P.M.	0.03	30.45	"
7:05 P.M.	0.03	30.45	"
7:10 P.M.	0.03	30.45	"
7:15 P.M.	0.03	30.45	"
7:20 P.M.	0.03	30.45	"
7:25 P.M.	0.03	30.45	"
7:30 P.M.	0.03	30.45	"
7:35 P.M.	0.03	30.45	"
7:40 P.M.	0.03	30.45	"
7:45 P.M.	0.03	30.45	"
7:50 P.M.	0.03	30.45	"
7:55 P.M.	0.03	30.45	"
8:00 P.M.	0.03	30.45	"

TABLE 9

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) RECORDED IN INCHES H_2O FROM THE INCLINED MANOMETER AT 5 MINUTE INTERVALS DURING A 20-HOUR PERIOD, DECEMBER 23-24, 1968, WITH A CONSTANT AIR FLOW OF 575 CFM INTO THE KING NO. 2 MINE

Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
3:15 P.M.	0.00	29.96	575 CFM
3:20 P.M.	0.01	29.96	"
3:25 P.M.	0.01	29.96	"
3:30 P.M.	0.01	29.96	"
3:35 P.M.	0.01	29.96	"
3:40 P.M.	0.01	29.96	"
3:45 P.M.	0.01	29.97	"
3:50 P.M.	0.01	29.97	"
3:55 P.M.	0.01	29.97	"
4:00 P.M.	0.01	29.97	"
4:05 P.M.	0.02	29.97	"
4:10 P.M.	0.02	29.97	"
4:15 P.M.	0.02	29.98	"
4:20 P.M.	0.03	29.98	"
4:25 P.M.	0.03	29.98	"
4:30 P.M.	0.03	29.98	"
4:35 P.M.	0.03	29.98	"
4:40 P.M.	0.03	29.98	"
4:45 P.M.	0.03	29.98	"
4:50 P.M.	0.03	29.98	"
4:55 P.M.	0.03	29.98	"
5:00 P.M.	0.03	29.99	"
5:05 P.M.	0.03	29.99	"
5:10 P.M.	0.03	29.99	"
5:15 P.M.	0.03	29.99	"
5:20 P.M.	0.03	29.99	"
5:25 P.M.	0.02	29.99	"
5:30 P.M.	0.02	29.99	"
5:35 P.M.	0.02	29.99	"
5:40 P.M.	0.02	29.99	"
5:45 P.M.	0.02	29.99	"
5:50 P.M.	0.02	29.99	"
5:55 P.M.	0.03	30.00	"
6:00 P.M.	0.03	30.00	"
6:05 P.M.	0.03	30.00	"
6:10 P.M.	0.05	30.00	"
6:15 P.M.	0.08	30.00	"
6:20 P.M.	0.08	30.00	"
6:25 P.M.	0.09	30.00	"
6:30 P.M.	0.10	30.00	"
6:35 P.M.	0.04	30.00	"
6:40 P.M.	0.06	30.00	"
6:45 P.M.	0.07	30.00	"

TABLE 9 (continued)

Time	Differential Mine Pressure, "H2O	Barometric Pressure, "Hg.	Air Flow
6:50 P.M.	0.07	30.00	575 CFM
6:55 P.M.	0.07	30.00	"
7:00 P.M.	0.07	30.00	"
7:05 P.M.	0.07	30.00	"
7:10 P.M.	0.07	30.00	"
7:15 P.M.	0.09	30.04	"
7:20 P.M.	0.07	30.04	"
7:25 P.M.	0.07	30.04	"
7:30 P.M.	0.07	30.04	"
7:35 P.M.	0.08	30.04	"
7:40 P.M.	0.08	30.04	"
7:45 P.M.	0.08	30.05	"
7:50 P.M.	0.09	30.05	"
7:55 P.M.	0.08	30.05	"
8:00 P.M.	0.08	30.05	"
8:05 P.M.	0.09	30.05	"
8:10 P.M.	0.06	30.05	"
8:15 P.M.	0.05	30.05	"
8:20 P.M.	0.05	30.05	"
8:25 P.M.	0.08	30.05	"
8:30 P.M.	0.09	30.05	"
8:35 P.M.	0.09	30.05	"
8:40 P.M.	0.08	30.05	"
8:45 P.M.	0.07	30.05	"
8:50 P.M.	0.08	30.05	"
8:55 P.M.	0.07	30.05	"
9:00 P.M.	0.03	30.05	"
9:05 P.M.	0.07	30.04	"
9:10 P.M.	0.06	30.04	"
9:15 P.M.	0.07	30.04	"
9:20 P.M.	0.10	30.04	"
9:25 P.M.	0.08	30.04	"
9:30 P.M.	0.09	30.04	"
9:35 P.M.	0.10	30.04	"
9:40 P.M.	0.12	30.04	"
9:45 P.M.	0.05	30.03	"
9:50 P.M.	0.07	30.03	"
9:55 P.M.	0.09	30.03	"
10:00 P.M.	0.06	30.02	"
10:05 P.M.	0.10	30.02	"
10:10 P.M.	0.10	30.02	"
10:15 P.M.	0.11	30.02	"
10:20 P.M.	0.11	30.02	"
10:25 P.M.	0.12	30.02	"
10:30 P.M.	0.12	30.02	"
10:35 P.M.	0.11	30.02	"
10:40 P.M.	0.11	30.02	"
10:45 P.M.	0.11	30.02	"

TABLE 9 (continued)

Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
10:50 P.M.	0.11	30.02	575 CFM
10:55 P.M.	0.11	30.02	"
11:00 P.M.	0.11	30.03	"
11:05 P.M.	0.12	30.03	"
11:10 P.M.	0.12	30.03	"
11:15 P.M.	0.12	30.03	"
11:20 P.M.	0.14	30.03	"
11:25 P.M.	0.13	30.03	"
11:30 P.M.	0.20	30.03	"
11:35 P.M.	0.12	30.03	"
11:40 P.M.	0.12	30.03	"
11:45 P.M.	0.12	30.03	"
11:50 P.M.	0.12	30.03	"
11:55 P.M.	0.14	30.03	"
12:00 M	0.12	30.03	"
12:05 A.M.	0.16	30.04	"
12:10 A.M.	0.13	30.04	"
12:15 A.M.	0.13	30.04	"
12:20 A.M.	0.15	30.04	"
12:25 A.M.	0.16	30.04	"
12:30 A.M.	0.14	30.05	"
12:35 A.M.	0.15	30.05	"
12:40 A.M.	0.15	30.05	"
12:45 A.M.	0.15	30.06	"
12:50 A.M.	0.15	30.06	"
12:55 A.M.	0.15	30.06	"
1:00 A.M.	0.15	30.06	"
1:05 A.M.	0.15	30.07	"
1:10 A.M.	0.18	30.07	"
1:15 A.M.	0.15	30.07	"
1:20 A.M.	0.15	30.07	"
1:25 A.M.	0.20	30.07	"
1:30 A.M.	0.28	30.08	"
1:35 A.M.	0.20	30.08	"
1:40 A.M.	0.15	30.08	"
1:45 A.M.	0.20	30.08	"
1:50 A.M.	0.15	30.08	"
1:55 A.M.	0.15	30.08	"
2:00 A.M.	0.18	30.08	"
2:05 A.M.	0.20	30.08	"
2:10 A.M.	0.16	30.08	"
2:15 A.M.	0.20	30.08	"
2:20 A.M.	0.18	30.08	"
2:25 A.M.	0.20	30.08	"
2:30 A.M.	0.20	30.08	"
2:35 A.M.	0.18	30.09	"
2:40 A.M.	0.18	30.09	"
2:45 A.M.	0.18	30.09	"

TABLE 9 (continued)

Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
2:50 A.M.	0.18	30.09	575 CFM
2:55 A.M.	0.18	30.09	"
3:00 A.M.	0.20	30.09	"
3:05 A.M.	0.20	30.09	"
3:10 A.M.	0.18	30.09	"
3:15 A.M.	0.18	30.09	"
3:20 A.M.	0.18	30.09	"
3:25 A.M.	0.18	30.09	"
3:30 A.M.	0.18	30.09	"
3:35 A.M.	0.18	30.09	"
3:40 A.M.	0.18	30.09	"
3:45 A.M.	0.26	30.09	"
3:50 A.M.	0.18	30.09	"
3:55 A.M.	0.20	30.09	"
4:00 A.M.	0.16	30.10	"
4:05 A.M.	0.20	30.10	"
4:10 A.M.	0.12	30.10	"
4:15 A.M.	0.18	30.10	"
4:20 A.M.	0.17	30.10	"
4:25 A.M.	0.17	30.10	"
4:30 A.M.	0.17	30.10	"
4:35 A.M.	0.17	30.10	"
4:40 A.M.	0.20	30.10	"
4:45 A.M.	0.18	30.10	"
4:50 A.M.	0.18	30.10	"
4:55 A.M.	0.18	30.10	"
5:00 A.M.	0.18	30.10	"
5:05 A.M.	0.18	30.11	"
5:10 A.M.	0.18	30.11	"
5:15 A.M.	0.18	30.11	"
5:20 A.M.	0.18	30.11	"
5:25 A.M.	0.18	30.11	"
5:30 A.M.	0.18	30.11	"
5:35 A.M.	0.18	30.11	"
5:40 A.M.	0.18	30.11	"
5:45 A.M.	0.16	30.11	"
5:50 A.M.	0.18	30.11	"
5:55 A.M.	0.18	30.11	"
6:00 A.M.	0.18	30.12	"
6:05 A.M.	0.18	30.12	"
6:10 A.M.	0.18	30.12	"
6:15 A.M.	0.18	30.12	"
6:20 A.M.	0.18	30.13	"
6:25 A.M.	0.22	30.13	"
6:30 A.M.	0.18	30.13	"
6:35 A.M.	0.18	30.13	"
6:40 A.M.	0.18	30.13	"
6:45 A.M.	0.20	30.13	"

TABLE 9 (continued)

Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
6:50 A.M.	0.20	30.13	575 CFM
6:55 A.M.	0.20	30.13	"
7:00 A.M.	0.20	30.13	"
7:05 A.M.	0.20	30.14	"
7:10 A.M.	0.18	30.14	"
7:15 A.M.	0.18	30.14	"
7:20 A.M.	0.18	30.14	"
7:25 A.M.	0.20	30.14	"
7:30 A.M.	0.20	30.14	"
7:35 A.M.	0.24	30.14	"
7:40 A.M.	0.20	30.14	"
7:45 A.M.	0.18	30.14	"
7:50 A.M.	0.18	30.15	"
7:55 A.M.	0.18	30.15	"
8:00 A.M.	0.18	30.15	"
8:00 A.M.	0.18	30.15	"
8:05 A.M.	0.18	30.15	"
8:10 A.M.	0.18	30.15	"
8:15 A.M.	0.18	30.15	"
8:20 A.M.	0.18	30.16	"
8:25 A.M.	0.18	30.16	"
8:30 A.M.	0.18	30.16	"
8:35 A.M.	0.18	30.16	"
8:40 A.M.	0.18	30.16	"
8:45 A.M.	0.18	30.16	"
8:50 A.M.	0.18	30.16	"
8:55 A.M.	0.18	30.16	"
9:00 A.M.	0.18	30.16	"
9:05 A.M.	0.18	30.17	"
9:10 A.M.	0.18	30.17	"
9:15 A.M.	0.18	30.17	"
9:20 A.M.	0.18	30.17	"
9:25 A.M.	0.18	30.17	"
9:30 A.M.	0.18	30.17	"
9:35 A.M.	0.18	30.18	"
9:40 A.M.	0.18	30.18	"
9:45 A.M.	0.18	30.18	"
9:50 A.M.	0.17	30.18	"
9:55 A.M.	0.17	30.18	"
10:00 A.M.	0.16	30.18	"
10:05 A.M.	0.15	30.19	"
10:10 A.M.	0.15	30.19	"
10:15 A.M.	0.13	30.19	"
10:20 A.M.	0.15	30.20	"
10:25 A.M.	0.15	30.20	"
10:30 A.M.	0.14	30.20	"
10:35 A.M.	0.14	30.21	"
10:40 A.M.	0.14	30.21	"
10:45 A.M.	0.15	30.21	"

TABLE 9 (continued)

Time	Differential Mine Pressure, "H2O	Barometric Pressure, "Hg.	Air Flow
10:50 A.M.	0.13	30.20	575 CFM
10:55 A.M.	0.13	30.20	"
11:00 A.M.	0.13	30.20	"
11:05 A.M.	0.12	30.20	"
11:10 A.M.	0.13	30.20	"
11:15 A.M.	0.13	30.20	"
11:20 A.M.	0.13	30.20	"
11:25 A.M.	0.13	30.20	"
11:30 A.M.	0.13	30.20	370 CFM
11:35 A.M.	0.09	30.20	"
11:40 A.M.	0.10	30.20	"
11:45 A.M.	0.10	30.20	"
11:50 A.M.	0.10	30.20	"
11:55 A.M.	0.10	30.20	"
12:00 N	0.10	30.20	"
12:05 P.M.	0.10	30.20	"
12:10 P.M.	0.09	30.20	"
12:20 P.M.	0.10	30.20	"
12:25 P.M.	0.10	30.20	"
12:30 P.M.	0.10	30.20	"
12:35 P.M.	0.10	30.20	"
12:40 P.M.	0.09	30.20	"
12:45 P.M.	0.09	30.20	"
12:50 P.M.	0.09	30.20	"
12:55 P.M.	0.09	30.20	"
1:00 P.M.	0.09	30.20	"
1:05 P.M.	0.05	30.20	325 CFM
1:10 P.M.	0.06	30.20	"
1:15 P.M.	0.07	30.20	"
1:20 P.M.	0.07	30.20	"
1:25 P.M.	0.07	30.20	"
1:30 P.M.	0.06	30.20	"
1:35 P.M.	0.03	30.20	"
1:40 P.M.	0.05	30.20	"
1:45 P.M.	0.05	30.20	"
1:50 P.M.	0.05	30.20	"
1:55 P.M.	0.05	30.20	"
2:00 P.M.	0.05	30.20	"
2:05 P.M.	0.05	30.20	"
2:10 P.M.	0.04	30.20	"
2:15 P.M.	0.03	30.20	"
2:20 P.M.	0.03	30.20	"
2:25 P.M.	0.06	30.20	"
2:30 P.M.	0.07	30.20	"
2:35 P.M.	0.07	30.20	"
2:40 P.M.	0.07	30.20	"
2:45 P.M.	0.06	30.20	"

TABLE 9 (continued)

Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.	Air Flow
2:50 P.M.	0.07	30.20	325 CFM
2:55 P.M.	0.05	30.20	"
3:00 P.M.	0.06	30.20	"
3:05 P.M.	0.06	30.20	"
3:10 P.M.	0.05	30.20	"
3:15 P.M.	0.06	30.20	"

Based upon the data collected from the Whipkey and King No. 2 mine sites, it was decided that the study should be continued at both sites using higher gas injection rates in order to determine the rate of leakage from these mines. To accomplish this task, the original rotary, displacement type blower was replaced with a high volume centrifugal blower (Dayton, Model No. 4C131). The blower was equipped with a butterfly valve in order to regulate the volume of air being pumped into the mine and flow rates were measured by an orifice plate. The only other modification required was the replacement of the 4" diameter injection pipe with a larger capacity pipe (10" diameter).

The required modifications, equipment servicing and recalibration were completed on April 13, 1969, and the motor-blower assembly was started at an initial air flow rate of 56 cu. m/minute (2,000 cfm). The recording instruments were not used during the first week of testing due to the mechanical failure of the alternator; however, mine differential pressures were recorded manually during this period. The air flow rate was maintained at 56 cu. m/minute (2,000 cfm) throughout this period and min pressure differentials fluctuated between 0.89 and 1.96 cm (0.35 and 0.77") H_2O. An analysis of the data collected at the end of this one week period failed to reveal any definite correlations between mine pressure differentials and barometric pressure changes and a definite pattern could not be established between mine pressures and air injection rates.

When the alternator was replaced and operation of the electrical recording instruments was resumed, it was apparent that the sporadic fluctuations of the recorded mine pressure did not correspond to the mine pressures indicated on the inclined manometer. An investigation revealed that condensation was occurring in the 1/4" aluminum tubing which was used for pressure measurements. This condensation restricted flow through the tubing, which consequently, resulted in erroneous pressure readings. In order to eliminate this situation, the 1/4" aluminum tubing was replaced with 3/8" copper tubing and the tubing was taken through the mine seal into a stoppered five gallon glass bottle in order to stabilize temperature variations. Pressure measurements were then taken from the glass bottle rather than directly from the mine. This modification resulted in a closer agreement between recorded and observed mine pressure and relative stabilization of mine pressures at various pumping rates. However, some of the mine pressure fluctuations persisted and seemed to confirm the previous theory that there was a relationship between wind direction and velocity and mine pressure fluctuations. This relationship was even more apparent during those periods when the blower was down for repairs or maintenance.

Based on the assumption that these fluctuations were caused by the passage of wind over or through a relatively large opening into the mine, the overlying area was again searched in the hopes of locating the mine opening. This investigation was focused on areas of shallow overburden, particularly those areas above mine entries or suspected haulageways. The investigation resulted in the location of a sizeable air leak near the original mine air course opening. This opening was approximately 8" square and the area surrounding the opening was highly fractured and porous (see Figure 23). There was less than 8' of overburden above the coal seam at this particular location. Figure 24 is a photograph of the original mine air course opening showing the approximate location of the air leakage area.

In order to fully characterize the affects of this fracture zone on mine pressurization under varying pumping rates and atmospheric conditions, the opening was not sealed at this time. It was also felt that this opening would afford an excellent test site for the evaluation of future leak detection studies.

Air injection was continued at various pumping rates and barometric pressure cycles through mid-September, 1969. The results were encouraging; even though considerable air leakage was occurring through the fracture area previously described, slight differential mine pressures could be maintained at air injection rates as low as 25.2 cu. m/minute (900 cfm). The test results also seemed to indicate that the barometric pressure has little or no effect on mine pressure differentials and that mine pressure will immediately dissipate with the cessation of air injection. The data collected during this period is tabulated in Tables 10 through 30. Figure 25 illustrates the affects of rapid barometric pressure changes on mine differential pressures during this period.

In early December, 1969, the fracture area was sealed by compacting the area with an impervious clay material. Prior

TABLE 10

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1900 CFM INTO THE KING NO. 2 MINE FOR 44-1/2 HOUR PERIOD, APRIL 20-22, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
4/20/69	2:00 P.M.	0.40	30.12
	2:30 P.M.	"	"
	3:00 P.M.	"	"
	3:30 P.M.	"	"
	4:00 P.M.	"	"
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
4/21/69	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	0.39	"
	3:30 A.M.	0.40	"
	4:00 A.M.	0.41	"
	4:30 A.M.	0.40	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	"

TABLE 10(Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
4/21/69	8:30 A.M.	0.40	30.11
	9:00 A.M.	"	30.09
	9:30 A.M.	"	30.08
	10:00 A.M.	"	30.06
	10:30 A.M.	"	30.05
	11:00 A.M.	0.39	30.03
	11:30 A.M.	"	30.02
	12:00 N		30.00
	12:30 P.M.	0.40	29.99
	1:00 P.M.	"	29.97
	1:30 P.M.	"	29.96
	2:00 P.M.	"	29.95
	2:30 P.M.	"	29.94
	3:00 P.M.	"	29.92
	3:30 P.M.	"	29.91
	4:00 P.M.	"	29.89
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	0.41	"
	9:00 P.M.	0.40	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
4/22/69	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	0.41	"

TABLE 10 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
4/22/69	5:30 A.M.	0.40	29.89
	6:00 A.M.	"	29.88
	6:30 A.M.	"	29.87
	7:00 A.M.	"	29.86
	7:30 A.M.	"	29.85
	8:00 A.M.	"	29.84
	8:30 A.M.	"	29.82
	9:00 A.M.	0.41	29.80
	9:30 A.M.	0.40	29.78
	10:00 A.M.	"	29.76
	10:30 A.M.	"	29.75

TABLE 11

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1780 CFM INTO THE KING NO. 2 MINE FOR 29 HOUR PERIOD, APRIL 22-23, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
4/22/69	11:00 A.M.	0.35	29.74
	11:30 A.M.	0.33	29.73
	12:00 N	0.35	29.72
	12:30 P.M.	0.34	29.71
	1:00 P.M.	0.37	"
	1:30 P.M.	0.36	"
	2:00 P.M.	"	"
	2:30 P.M.	0.37	"
	3:00 P.M.	0.38	"
	3:30 P.M.	0.35	"
	4:00 P.M.	0.30	"
	4:30 P.M.	0.35	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	0.34	"
	6:30 P.M.	0.35	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	0.33	"
	8:30 P.M.	0.35	"
	9:00 P.M.	0.34	"
	9:30 P.M.	0.35	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11;30 P.M.	"	"
4/23/69	12:00 M	"	"
	12:30 A.M.	0.36	"
	1:00 A.M.	0.35	"
	1:30 A.M.	"	"
	2:00 A.M.	0.34	"
	2:30 A.M.	0.35	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"

TABLE 11(Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
4/23/69	5:30 A.M.	0.35	29.71
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	"	"
	9:00 A.M.	"	"
	9:30 A.M.	"	29.72
	10:00 A.M.	0.34	"
	10:30 A.M.	0.35	"
	11:00 A.M.	"	"
	11:30 A.M.	"	"
	12:00 N	"	"
	12:30 P.M.	"	"
	1:00 P.M.	0.36	"
	1:30 P.M.	0.35	"
	2:00 P.M.	"	"
	2:30 P.M.	0.37	29.73
	3:00 P.M.	0.35	29.75
	3:30 P.M.	"	29.76
	4:00 P.M.	0.36	29.77

TABLE 12

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1580 CFM INTO THE KING NO. 2 MINE FOR 3 HOUR PERIOD, APRIL 30, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
4/30/69	12:00 N	0.30	30.15
	12:30 P.M.	"	"
	1:00 P.M.	"	"
	1:30 P.M.	0.39	"
	2:00 P.M.	0.40	"
	2:30 P.M.	"	"
	3:00 P.M.	"	30.14

TABLE 13

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1580 CFM INTO THE KING NO. 2 MINE FOR 7 HOUR PERIOD, MAY 1, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/1/69	10:30 A.M.	0.30	30.22
	11:00 A.M.	"	"
	11:30 A.M.	"	30.23
	12:00 N	0.29	30.24
	12:30 P.M.	0.30	"
	1:00 P.M.	"	30.23
	1:30 P.M.	0.29	"
	2:00 P.M.	0.30	30.22
	2:30 P.M.	"	"
	3:00 P.M.	"	30.21
	3:30 P.M.	0.29	"
	4:00 P.M.	0.30	30.20
	4:30 P.M.	"	30.19
	5:00 P.M.	"	30.18
	5:30 P.M.	"	"

TABLE 14

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 2000 CFM INTO THE KING NO. 2 MINE FOR 5 HOUR PERIOD, MAY 2, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/2/69	12:00 N	0.40	30.21
	12:30 P.M.	0.42	"
	1:00 P.M.	0.41	30.20
	1:30 P.M.	0.39	"
	2:00 P.M.	0.40	30.19
	2:30 P.M.	0.38	"
	3:00 P.M.	0.40	30.18
	3:30 P.M.	"	30.17
	4:00 P.M.	0.41	30.16
	4:30 P.M.	0.40	30.15
	5:00 P.M.	"	30.14

TABLE 14 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/7/69	4:00 A.M.	0.14	30.00
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	"	30.01
	6:30 A.M.	"	"
	7:00 A.M.	"	30.02
	7:30 A.M.	"	"
	8:00 A.M.	"	30.03
	8:30 A.M.	"	"
	9:00 A.M.	0.13	"
	9:30 A.M.	0.14	30.04
	10:00 A.M.	"	30.05
	10:30 A.M.	"	"

TABLE 15

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 960 CFM INTO THE KING NO. 2 MINE FOR 24 HOUR PERIOD, MAY 6-7, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/6/69	10:30 A.M.	0.18	30.04
	11:00 A.M.	0.14	"
	11:30 A.M	0.13	30.03
	12:00 N.	0.14	"
	12:30 P.M.	0.15	"
	1:00 P.M.	"	30.02
	1:30 P.M.	0.14	"
	2:00 P.M.	"	"
	2:30 P.M.	"	"
	3:00 P.M.	"	30.01
	3:30 P.M.	"	30.00
	4:00 P.M.	"	29.99
	4:30 P.M.	0.15	"
	5:00 P.M.	0.14	"
	5:30 P.M.	0.15	"
	6:00 P.M.	0.14	"
	6:30 P.M.	0.15	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	0.14	"
	8:30 P.M.	"	"
	9:00 P.M.	"	30.00
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
5/7/69	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	0.13	"
	2:00 A.M.	0.14	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"

TABLE 15 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/8/69	5:30 A.M.	0.17	30.00
	6:00 A.M.	"	29.99
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	30.01
	8:30 A.M.	"	"
	9:00 A.M.	"	"
	9:30 A.M.	"	29.99
	10:00 A.M.	"	"
	10:30 A.M.	"	"

TABLE 16

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1200 CFM INTO THE KING NO. 2 MINE FOR 23-1/2 HOUR PERIOD, MAY 7-8, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/7/69	11:00 A.M.	0.18	30.06
	11:30 A.M.	0.17	"
	12:00 N	0.18	"
	12:30 P.M.	"	"
	1:00 P.M.	"	"
	1:30 P.M.	0.19	30.05
	2:00 P.M.	"	30.04
	2:30 P.M.	0.18	30.03
	3:00 P.M.	"	30.02
	3:30 P.M.	0.20	"
	4:00 P.M.	0.18	"
	4:30 P.M.	0.20	"
	5:00 P.M.	0.18	"
	5:30 P.M.	"	30.01
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	0.17	"
	9:30 P.M.	"	"
	10:00 P.M.	0.18	30.02
	10:30 P.M.	0.17	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
5/8/69	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	0.18	"
	1:30 A.M.	0.17	"
	2:00 A.M.	"	"
	2:30 A.M.	"	30.01
	3:00 A.M.	"	"
	3:30 A.M.	"	30.00
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"

TABLE 17

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1400 CFM INTO THE KING NO. 2 MINE FOR 23-1/2 HOUR PERIOD, MAY 8-9, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/8/69	11:00 A.M.	0.22	29.98
	11:30 A.M.	0.21	29.97
	12:00 N	0.22	29.96
	12:30 P.M.	"	29.95
	1:00 P.M.	"	29.93
	1:30 P.M.	0.20	29.92
	2:00 P.M.	0.22	29.90
	2:30 P.M.	"	"
	3:00 P.M.	0.23	29.89
	3:30 P.M.	0.22	29.88
	4:00 P.M.	0.23	29.86
	4:30 P.M.	"	29.85
	5:00 P.M.	0.22	"
	5:30 P.M.	"	"
	6:00 P.M.	0.21	29.84
	6:30 P.M.	0.23	"
	7:00 P.M.	0.22	29.83
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	0.23	"
	9:00 P.M.	0.22	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	29.82
	11:30 P.M.	"	"
5/9/69	12:00 M	0.20	29.81
	12:30 A.M.	0.19	"
	1:00 A.M.	"	29.80
	1:30 A.M.	0.21	"
	2:00 A.M.	0.22	29.79
	2:30 A.M.	"	"
	3:00 A.M.	"	29.78
	3:30 A.M.	0.21	29.77
	4:00 A.M.	0.22	29.76
	4:30 A.M.	"	29.75
	5:00 A.M.	"	29.74

TABLE 17 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/9/69	5:30 A.M.	0.22	29.73
	6:00 A.M.	"	"
	6:30 A.M.	0.23	29.72
	7:00 A.M.	0.22	"
	7:30 A.M.	"	"
	8:00 A.M.	"	29.71
	8:30 A.M.	"	"
	9:00 A.M.	0.23	29.72
	9:30 A.M.	0.25	29.69
	10:00 A.M.	0.24	29.64
	10:30 A.M.	"	"

TABLE 18

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1580 CFM INTO THE KING NO. 2 MINE FOR 5-1/2 HOUR PERIOD, MAY 9, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/9/69	11:00 A.M.	0.29	29.64
	11:30 A.M.	0.28	"
	12:00 N	"	"
	12:30 P.M.	0.30	"
	1:00 P.M.	"	"
	1:30 P.M.	0.32	"
	2:00 P.M.	0.30	29.65
	2:30 P.M.	"	"
	3:00 P.M.	"	"
	3:30 P.M.	0.27	"
	4:00 P.M.	0.32	"
	4:30 P.M.	0.31	"

TABLE 19

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1580 CFM INTO THE KING NO. 2 MINE FOR 25-1/2 HOUR PERIOD, MAY 14-15, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/14/69	9:00 A.M.	0.25	30.14
	9:30 A.M.	0.28	"
	10:00 A.M.	"	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	"	30.15
	12:00 N	0.29	"
	12:30 P.M.	0.28	"
	1:00 P.M.	"	30.14
	1:30 P.M.	"	"
	2:00 P.M.	"	30.13
	2:30 P.M.	0.27	"
	3:00 P.M.	0.28	"
	3:30 P.M.	0.30	"
	4:00 P.M.	0.27	"
	4:30 P.M.	0.28	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	0.27	"
	7:30 P.M.	0.28	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	30.14
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
5/15/69	12:00 M	"	30.15
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	30.16
	2:30 A.M.	"	"

TABLE 19 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/15/69	3:00 A.M.	0.28	30.16
	3:30 A.M.	"	"
	4:00 A.M.	"	30.17
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	"	30.18
	6:30 A.M.	"	"
	7:00 A.M.	"	30.19
	7:30 A.M.	"	30.20
	8:00 A.M.	"	30.21
	8:30 A.M.	"	"
	9:00 A.M.	"	30.22
	9:30 A.M.	0.27	"
	10:00 A.M.	0.28	"
	10:30 A.M.	"	"

TABLE 20

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1750 CFM INTO THE KING NO. 2 MINE FOR 5 HOUR PERIOD, MAY 15, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/15/69	11:00 A.M.	0.31	30.22
	11:30 A.M.	"	30.21
	12:00 N	"	"
	12:30 P.M.	0.32	"
	1:00 P.M.	"	30.20
	1:30 P.M.	0.31	"
	2:00 P.M.	"	30.19
	2:30 P.M.	"	"
	3:00 P.M.	"	30.18
	3:30 P.M.	"	"
	4:00 P.M.	"	30.17

TABLE 21

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1895 CFM INTO THE KING NO. 2 MINE FOR 7 HOUR PERIOD, MAY 16, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/16/69	10:30 A.M.	0.36	30.21
	11:00 A.M.	"	30.20
	11:30 A.M.	0.37	30.19
	12:00 N	"	30.18
	12:30 P.M.	0.36	30.17
	1:00 P.M.	"	30.16
	1:30 P.M.	"	30.15
	2:00 P.M.	"	30.14
	2:30 P.M.	0.37	30.13
	3:00 P.M.	0.36	30.12
	3:30 P.M.	"	"
	4:00 P.M.	"	"
	4:30 P.M.	-0.01*	"

* Blower stopped

TABLE 22

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1920 CFM INTO THE KING NO. 2 MINE FOR 52-1/2 HOUR PERIOD, MAY 19-21, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/19/69	10:00 A.M.	0.33	30.04
	10:30 A.M.	0.35	"
	11:00 A.M.	0.37	"
	11:30 A.M.	0.35	"
	12:00 N	0.37	30.03
	12:30 P.M.	"	"
	1:00 P.M.	0.36	30.02
	1:30 P.M.	0.37	"
	2:00 P.M.	"	30.01
	2:30 P.M.	"	"
	3:00 P.M.	0.38	30.00
	3:30 P.M.	0.37	"
	4:00 P.M.	"	"
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	0.38	"
	7:00 P.M.	0.37	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	0.36	"
	9:30 P.M.	0.37	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
5/20/69	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	0.36	"
	1:30 A.M.	0.37	"
	2:00 A.M.	"	"
	2:30 A.M.	0.36	"
	3:00 A.M.	0.37	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"

TABLE 22 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/20/69	5:00 A.M.	0.37	30.00
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	"	30.01
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	"	"
	9:00 A.M.	"	"
	9:30 A.M.	"	"
	10:00 A.M.	"	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	"	"
	12:00 N	"	30.02
	12:30 P.M.	"	30.01
	1:00 P.M.	0.38	"
	1:30 P.M.	0.37	"
	2:00 P.M.	0.36	"
	2:30 P.M.	0.37	"
	3:00 P.M.	"	"
	3:30 P.M.	"	"
	4:00 P.M.	"	"
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	0.36	"
	7:30 P.M.	0.37	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	30.02
	9:30 P.M.	"	30.03
	10:00 P.M.	"	30.04
	10:30 P.M.	"	30.05
	11:00 P.M.	"	30.06
	11:30 P.M.	"	30.07
5/21/69	12:00 M	"	30.08
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"

TABLE 22 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/21/69	2:00 A.M.	0.37	30.09
	2:30 A.M.	"	30.10
	3:00 A.M.	"	"
	3:30 A.M.	"	30.11
	4:00 A.M.	"	30.12
	4:30 A.M.	"	30.13
	5:00 A.M.	"	30.14
	5:30 A.M.	"	30.15
	6:00 A.M.	0.36	30.16
	6:30 A.M.	0.37	30.17
	7:00 A.M.	"	"
	7:30 A.M.	"	30.18
	8:00 A.M.	"	30.19
	8:30 A.M.	"	30.20
	9:00 A.M.	0.36	30.21
	9:30 A.M.	"	30.22
	10:00 A.M.	0.37	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	"	"
	12:00 N	0.36	"
	12:30 P.M.	0.37	"
	1:00 P.M.	"	"
	1:30 P.M.	0.38	"
	2:00 P.M.	"	"
	2:30 P.M.	0.37	"
			"

TABLE 23

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1930 CFM INTO THE KING NO. 2 MINE FOR 4 HOUR PERIOD, MAY 22, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/22/69	1:30 P.M.	0.36	30.16
	2:00 P.M.	0.37	"
	2:30 P.M.	"	"
	3:00 P.M.	"	"
	3:30 P.M.	"	"
	4:00 P.M.	"	"
	4:30 P.M.	0.38	"
	5:00 P.M.	0.37	"
	5:30 P.M.	"	"

TABLE 24

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1980 CFM INTO THE KING NO. 2 MINE FOR 15 HOUR PERIOD, MAY 22-23, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/22/69	6:00 P.M.	0.38	30.16
	6:30 P.M.	0.37	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
5/23/69	12:00 M	0.36	"
	12:30 A.M.	0.37	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	0.36	"
	4:00 A.M.	0.37	"
	4:30 A.M.	"	"
	5:00 A.M.	0.38	"
	5:30 A.M.	0.37	"
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	30.17
	8:30 A.M.	"	"
	9:00 A.M.	0.36	"

TABLE 25

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1940 CFM INTO THE KING NO. 2 MINE FOR 6-1/2 HOUR PERIOD, MAY 23, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/23/69	9:30 A.M.	0.37	30.17
	10:00 A.M.	"	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11 30 A.M.	"	"
	12:00 N	0.38	"
	12:30 P.M.	0.37	"
	1:00 P.M.	"	"
	1:30 P.M.	"	"
	2:00 P.M.	"	30.16
	2:30 P.M.	"	30.15
	3:00 P.M.	"	30.13
	3:30 P.M.	"	30.12
	4:00 P.M.	"	"

TABLE 26

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1760 CFM INTO THE KING NO. 2 MINE FOR 52-1/2 HOUR PERIOD, MAY 27-29, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/27/69	1:30 P.M.	0.30	30.27
	2:00 P.M.	"	"
	2:30 P.M.	0.31	30.26
	3:00 P.M.	"	30.25
	3:30 P.M.	"	30.24
	4:00 P.M.	0.30	30.23
	4:30 P.M.	0.31	"
	5:00 P.M.	"	"
	5:30 P.M.	0.30	30.22
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	0.29	"
	11:30 P.M.	0.30	"
5/28/69	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	30.23
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	"	30.24
	7:30 A.M.	"	"

TABLE 26 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/28/69	8:00 A.M.	0.30	30.24
	8:30 A.M.	"	"
	9:00 A.M.	0.31	"
	9:30 A.M.	"	"
	10:00 A.M.	"	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	0.30	"
	12:00 N	0.31	30.23
	12:30 P.M.	"	30.22
	1:00 P.M.	"	30.21
	1:30 P.M.	"	30.20
	2:00 P.M.	"	30.19
	2:30 P.M.	"	30.18
	3:00 P.M.	"	30.17
	3:30 P.M.	"	30.16
	4:00 P.M.	"	30.15
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	0.30	"
	6:00 P.M.	"	30.14
	6:30 P.M.	"	"
	7:00 P.M.	"	30.13
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
5/29/69	12:00	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	30.12
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"

TABLE 26 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
5/29/69	5:00 A.M.	0.30	30.12
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	"	"
	9:00 A.M.	"	"
	9:30 A.M.	"	30.11
	10:00 A.M.	"	30.10
	10:30 A.M.	"	"
	11:00 A.M.	0.31	30.09
	11:30 A.M.	0.30	"
	12:00 N	"	30.08
	12:30 P.M.	"	"
	1:00 P.M.	"	30.07
	1:30 P.M.	"	"
	2:00 P.M.	0.31	30.06
	2:30 P.M.	"	30.05
	3:00 P.M.	"	30.04
	3:30 P.M.	0.30	30.03
	4:00 P.M.	"	30.02
	4:30 P.M.	0.29	30.01
	5:00 P.M.	0.30	30.00
	5:30 P.M.	"	29.99
	6:00 P.M.	"	29.98

TABLE 27

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 900 CFM INTO THE KING NO. 2 MINE FOR 8 HOUR PERIOD, JULY 18, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
7/18/69	9:00 A.M.	0.30	30.17
	9:30 A.M.	"	"
	10:00 A.M.	0.12	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	"	"
	12:00 N	"	"
	12:30 P.M.	"	"
	1:00 P.M.	"	"
	1:30 P.M.	"	"
	2:00 P.M.	"	30.16
	2:30 P.M.	"	30.15
	3:00 P.M.	"	30.14
	3:30 P.M.	0.11	30.13
	4:00 P.M.	0.12	30.12
	4:30 P.M.	"	"
	5:00 P.M.	"	"

TABLE 28

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1660 CFM INTO THE KING NO. 2 MINE FOR 22 HOUR PERIOD, AUGUST 4-5, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
8/4/69	9:00 A.M.	0.30	30.05
	9:30 A.M.	"	"
	10:00 A.M.	0.31	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	"	"
	12:00 N	"	"
	12:30 P.M.	0.30	"
	1:00 P.M.	"	"
	1:30 P.M.	0.31	"
	2:00 P.M.	"	"
	2:30 P.M.	"	"
	3:00 P.M.	"	"
	3:30 P.M.	"	"
	4:00 P.M.	"	"
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
8/5/69	12:00 M	"	"
	12:30 A.M.	0.30	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"

TABLE 28 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
8/5/69	2:30 A.M.	0.30	30.05
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	0.29	"
	7:00 A.M.	0.30	"
	7:30 A.M.	0.31	"
	8:00 A.M.	"	"

TABLE 29

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1780 CFM INTO THE KING NO. 2 MINE FOR 25 HOUR PERIOD, SEPTEMBER 10-11, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
9/10/69	9:30 A.M.	0.29	30.19
	10:00 A.M.	0.30	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	"	"
	12:00 N	"	30.18
	12:30 P.M.	"	"
	1:00 P.M.	"	"
	1:30 P.M.	"	"
	2:00 P.M.	0.32	30.17
	2:30 P.M.	0.31	"
	3:00 P.M.	0.30	"
	3:30 P.M.	"	30.16
	4:00 P.M.	"	"
	4:30 P.M.	0.31	"
	5:00 P.M.	"	"
	5:30 P.M.	0.30	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	30.17
	8:30 P.M.	"	"
	9:00 P.M.	0.29	"
	9:30 P.M.	0.30	"
	10:00 P.M.	"	30.18
	10:30 P.M.	"	"
	11:00 P.M.	0.29	"
	11:30 P.M.	0.30	"
9/11/69	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	0.29	"
	3:30 A.M.	0.30	"

TABLE 29 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
9/11/69	4:00 A.M.	0.30	30.19
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	0.31	"
	9:00 A.M.	"	"
	9:30 A.M.	0.30	30.20
	10:00 A.M.	0.31	"
	10:30 A.M.	0.30	"

TABLE 30

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1720 CFM INTO THE KING NO. 2 MINE FOR 77 HOUR PERIOD, SEPTEMBER 11-16, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
9/11/69	11:00 A.M.	0.30	30.20
	11:30 A.M.	0.31	"
	12:00 N	0.30	"
	12:30 P.M.	"	"
	1:00 P.M.	"	"
	1:30 P.M.	"	"
	2:00 P.M.	0.29	"
	2:30 P.M.	0.30	"
	3:00 P.M.	"	"
	3:30 P.M.	0.29	"
	4:00 P.M.	0.30	"
	4:30 P.M.	"	30.19
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	0.29	"
	8:30 P.M.	0.30	"
	9:00 P.M.	0.29	"
	9:30 P.M.	"	"
	10:00 P.M.	0.30	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
9/12/69	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	0.29	"
	2:00 A.M.	0.30	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"

TABLE 30 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
9/12/69	6:00 A.M.	0.30	30.19
	6:30 A.M.	"	"
	7:00 A.M.	"	30.20
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	"	"
	9:00 A.M.	"	30.21
	9:30 A.M.	"	"
	10:00 A.M.	"	30.22
	10:30 A.M.	0.31	"
	11:00 A.M.	0.30	"
	11:30 A.M.	"	"
	12:00 N	"	"
	12:30 P.M.	0.29	"
	1:00 P.M.	0.30	"
	1:30 P.M.	"	30.21
	2:00 P.M.	0.29	30.20
	2:30 P.M.	0.30	30.19
	3:00 P.M.	"	"
	3:30 P.M.	0.0	"
	4:00 P.M.	0.30	30.18
	4:30 P.M.	0.31	"
	5:00 P.M.	0.30	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	30.19
	9:30 P.M.	0.29	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	0.30	"
	11:30 P.M.	"	"
9/13/69	12:00 M	"	"
	12:30 A.M.	0.29	"
	1:00 A.M.	0.30	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"

TABLE 30 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
9/13/69	3:00 A.M.	0.30	30.19
	3:30 A.M.	"	"
	4:00 A.M.	0.29	"
	4:30 A.M.	0.30	"
	5:00 A.M.	0.29	"
	5:30 A.M.	0.30	"
	6:00 A.M.	0.29	"
	6:30 A.M.	"	"
	7:00 A.M.	0.30	30.20
	7:30 A.M.	0.29	"
	8:00 A.M.	0.30	30.21
	8:30 A.M.	0.29	"
	9:00 A.M.	0.30	"
	9:30 A.M.	"	"
	10:00 A.M.	"	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	0.29	"
	12:00 N	"	"
	12:30 P.M.	0.30	"
	1:00 P.M.	"	"
	1:30 P.M.	"	"
	2:00 P.M.	"	"
	2:30 P.M.	0.29	"
	3:00 P.M.	0.30	30.20
	3:30 P.M.	"	"
	4:00 P.M.	"	"
	4:30 P.M.	"	"
	5:00 P.M.	"	30.19
	5:30 P.M.	"	"
	6:00 P.M.	0.31	"
	6:30 P.M.	"	"
	7:00 P.M.	0.30	"
	7:30 P.M.	0.31	"
	8:00 P.M.	0.30	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	30.20
	11:30 P.M.	"	"
9/14/69	12:00 M	"	"

TABLE 30 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
9/14/69	12:30 A.M.	0.30	30.20
	1:00 A.M.	0.29	"
	1:30 A.M.	0.30	"
	2:00 A.M.	"	"
	2:30 A.M.	0.29	"
	3:00 A.M.	0.30	"
	3:30 A.M.	"	"
	4:00 A.M.	0.29	"
	4:30 A.M.	0.30	"
	5:00 A.M.	"	30.21
	5:30 A.M.	0.29	"
	6:00 A.M.	"	"
	6:30 A.M.	0.28	"
	7:00 A.M.	0.29	"
	7:30 A.M.	0.30	"
	8:00 A.M.	"	30.22
	8:30 A.M.	"	"
	9:00 A.M.	0.29	"
	9:30 A.M.	0.30	"
	10:00 A.M.	0.29	30.23
	10:30 A.M.	0.30	"
	11:00 A.M.	"	"
	11:30 A.M.	0.29	"
	12:00 N	"	"
	12:30 P.M.	0.30	"
	1:00 P.M.	"	"
	1:30 P.M.	"	"
	2:00 P.M.	"	30.22
	2:30 P.M.	0.31	"
	3:00 P.M.	0.30	"
	3:30 P.M.	"	"
	4:00 P.M.	"	30.21
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	0.29	"
	6:00 P.M.	0.30	30.20
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	0.31	"
	8:00 P.M.	0.30	"

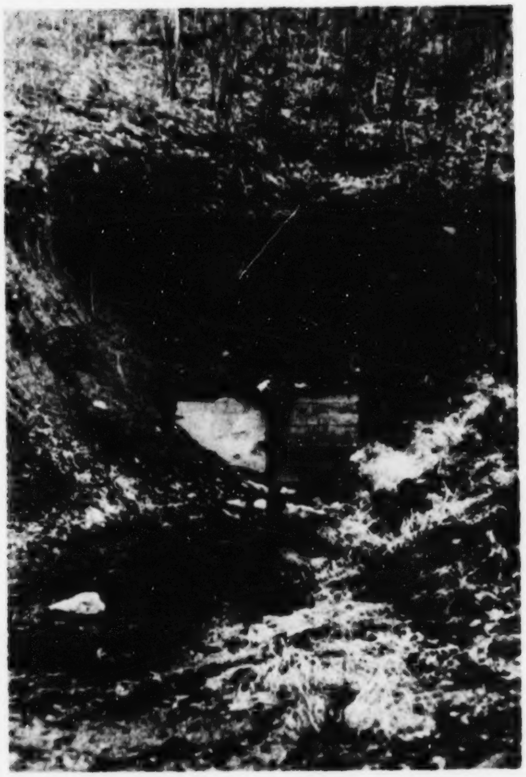
TABLE 30 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
9/14/69	8:30 P.M.	0.30	30.20
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	0.29	"
	10:30 P.M.	0.30	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
9/15/69	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	0.31	"
	1:30 A.M.	0.30	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	0.29	"
	4:30 A.M.	0.30	"
	5:00 A.M.	"	"
	5:30 A.M.	"	30.21
	6:00 A.M.	0.29	"
	6:30 A.M.	"	30.22
	7:00 A.M.	"	"
	7:30 A.M.	0.30	30.23
	8:00 A.M.	0.29	"
	8:30 A.M.	"	"
	9:00 A.M.	0.30	"
	9:30 A.M.	"	"
	10:00 A.M.	"	"
	10:30 A.M.	"	"
	11:00 A.M.	"	30.22
	11:30 A.M.	0.29	"
	12:00 N	0.30	30.21
	12:30 P.M.	"	"
	1:00 P.M.	"	30.20
	1:30 P.M.	"	"
	2:00 P.M.	0.29	30.19
	2:30 P.M.	0.30	"
	3:00 P.M.	"	30.18

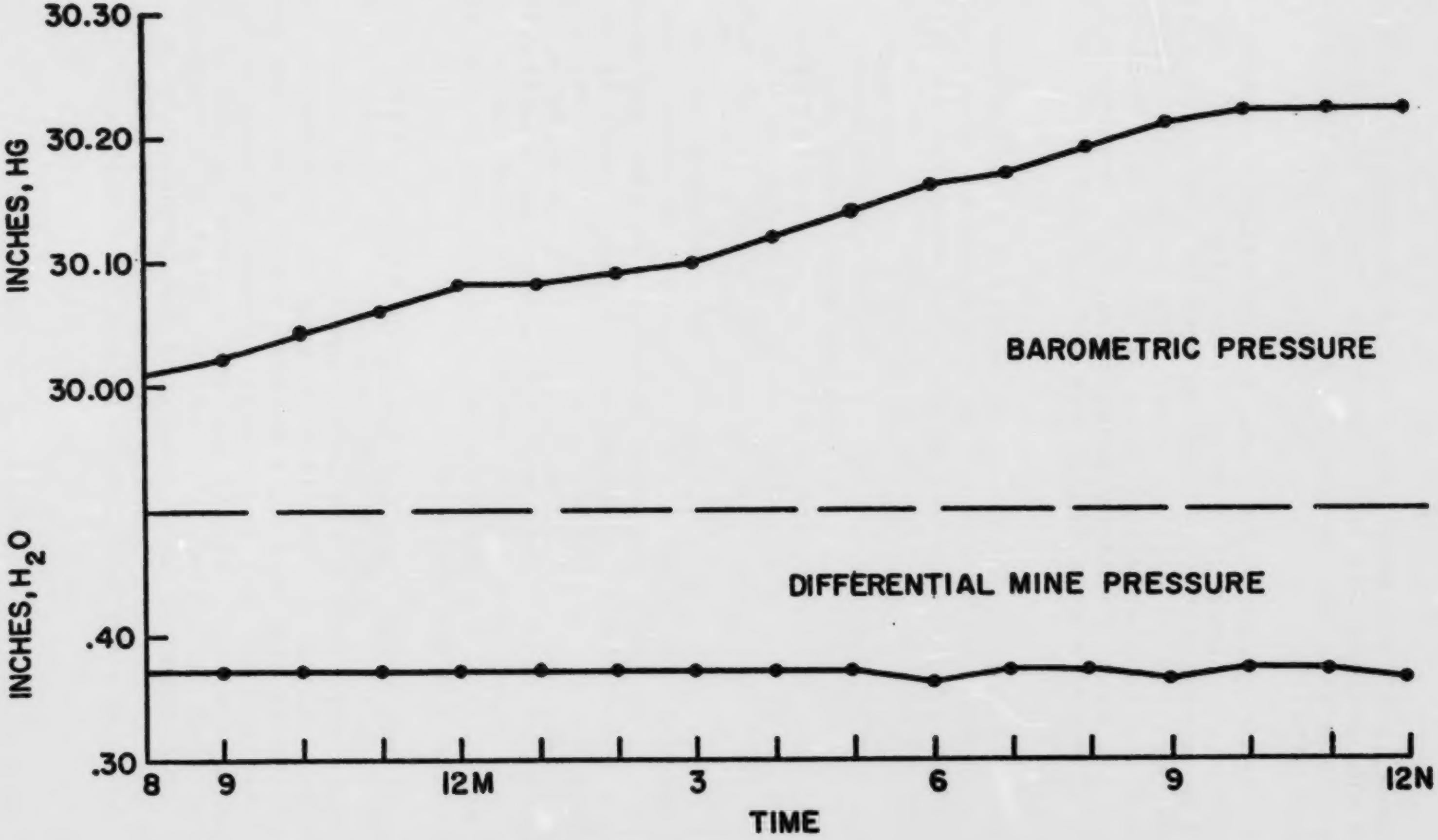
POINTS OF
AIR
LEAKAGE

AIR LEAKAGE AREA AT KING NO. 2 MINE SITE
FIGURE 23

FRACTURE
ZONE



KING NO. 2 MINE AIR COURSE
SHOWING LOCATION OF FRACTURE ZONE
FIGURE 24



MINE PRESSURE VS. BAROMETRIC PRESSURE AT AIR FLOW RATE OF 1920 CFM
KING NO. 2 MINE SITE, MAY 20 & 21, 1969

FIGURE 25

to sealing, a 4" diameter pipe was placed through the opening and the sealing was then completed around the pipe. This was done in order to provide an outlet for future leak detection studies.

Once the opening was sealed, the pressurization studies were continued with encouraging results; the air blowing rate was reduced by approximately 40-50% to produce pressures equal to those obtained in earlier runs. The results of these test runs are tabulated in Tables 31 through 34. Mechanical difficulties with the motor interferred with further testing at this time and air injection was not resumed until early January, 1970.

Prior to this forced shutdown, experiments were conducted with leak detection by the use of smoke bombs. These were commercially available smoke bombs which were specifically for locating points of leakage or infiltration into sanitary sewers. Each bomb burns for five minutes and produces 2800 cu. m (100,000 cubic feet) of white (phosphorous) smoke. Fifteen bombs were burned one after another into the air intake of the blower. Within a 90-minute period, 42,000 cu. m (1.5 million cubic feet) of smoke had been injected into the mine. The estimated volume of the King No. 2 mine is 64,400 cu. m (2.3 million cubic feet). The control hole, previously discussed, was observed for 24 hours, but neither smoke nor the odor of phosphorous was detected. A portable gas leak detector was also employed to verify the presence or absence of foreign gases in the atmosphere above the mine site as well as at the test hole. The particular gas leak detector used in this study was a Matheson Model 8013. This unit has a reported sensitivity of 9×10^{-5} standard cc/sec., however, repeated tests failed to confirm the presence of a foreign gas in the air exiting from the control port.

The blower motor was repaired in early January, 1970, and the leak detection studies were resumed. On January 6, 63 smoke bombs were burned one after another in the blower air intake. Although the distinct odor of phosphorous gas was detected at the test hole several hours after the initiation of testing and was noticeably present throughout this experiment, the smoke itself was never observed and it is theorized that it was adsorbed on the moist mine surfaces. The gas leak detector unit confirmed the presence of a foreign gas in the air blowing through the test hole but failed to locate any additional points of leakage.

TABLE 31

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1940 CFM INTO THE KING NO. 2 MINE FOR 3-1/2 HOUR PERIOD, DECEMBER 10, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
12/10/69	11:30 P.M.	0.80	29.93
	12:00 N	"	29.92
	12:30 P.M.	"	"
	1:00 P.M.	0.81	29.91
	1:30 P.M.	0.82	"
	2:00 P.M.	"	29.90
	2:30:P.M.	0.84	29.89
	3:00 P.M.	0.85	29.87

TABLE 32

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 900 CFM INTO THE KING NO. 2 MINE FOR 5 HOUR PERIOD, DECEMBER 10, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
12/10/69	3:30 P.M.	0.32	29.85
	4:00 P.M.	0.36	29.83
	4:30 P.M.	0.37	29.82
	5:00 P.M.	0.38	29.80
	5:30 P.M.	0.37	29.79
	6:00 P.M.	"	29.78
	6·30 P.M.	"	29.76
	7:00 P.M.	0.38	29.74
	7:30 P.M.	0.37	29.72
	8:00 P.M.	"	29.70
	8:30 P.M.	0.0	29.67

TABLE 33

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 500 CFM INTO THE KING NO. 2 MINE FOR 17-1/2 HOUR PERIOD, DECEMBER 11-12, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
12/11/69	3:30 P.M.	0.20	29.81
	4:00 P.M.	"	29.82
	4:30 P.M.	"	"
	5:00 P.M.	0.19	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	29.83
	7:30 P.M.	"	29.84
	8:00 P.M.	"	29.85
	8:30 P.M.	"	29.86
	9:00 P.M.	"	29.87
	9:30 P.M.	"	29.88
	10:00 P.M.	"	29.89
	10:30 P.M.	"	"
	11:00 P.M.	"	29.90
	11:30 P.M.	0.20	20.91
12/12/69	12:00 M	0.19	29.92
	12:30 A.M.	"	"
	1:00 A.M.	"	29.93
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	29.94
	3:30 A.M.	"	"
	4:00 A.M.	"	29.95
	4:30 A.M.	"	"
	5:00 A.M.	"	29.96
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	"	29.97
	7:00 A.M.	0.20	29.98
	7:30 A.M.	"	29.99
	8:00 A.M.	"	30.00
	8:30 A.M.	0.19	30.02
	9:00 A.M.	"	30.04

TABLE 34

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 540 CFM INTO THE KING NO. 2 MINE FOR 53 HOUR PERIOD, DECEMBER 12-14, 1969

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
12/12/69	11:00 A.M.	0.19	30.09
	11:30 A.M.	0.20	30.10
	12:00 N	"	"
	12:30 P.M.	0.19	"
	1:00 P.M.	0.20	"
	1:30 P.M.	"	"
	2:00 P.M.	0.19	"
	2:30 P.M.	"	"
	3:00 P.M.	"	"
	3:30 P.M.	"	"
	4:00 P.M.	"	"
	4:30 P.M.	0.18	"
	5:00 P.M.	"	"
	5:30 P.M.	0.17	"
	6:00 P.M.	0.19	"
	6:30 P.M.	0.18	30.11
	7:00 P.M.	"	"
	7:30 P.M.	"	30.12
	8:00 P.M.	"	30.13
	8:30 P.M.	0.16	30.14
	9:00 P.M.	0.12	30.15
	9:30 P.M.	0.15	"
	10:00 P.M.	0.18	30.16
	10:30 P.M.	0.19	"
	11:00 P.M.	0.18	"
	11:30 P.M.	"	"
12/13/69	12:00 M	0.19	"
	12:30 A.M.	0.17	"
	1:00 A.M.	0.18	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"

TABLE 34 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
12/13/69	6:00 A.M.	0.18	30.16
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	30.17
	8:30 A.M.	"	"
	9:00 A.M.	"	"
	9:30 A.M.	0.17	"
	10:00 A.M.	0.18	"
	10:30 A.M.	0.17	"
	11:00 A.M.	"	"
	11:30 A.M.	0.19	"
	12:00 N	0.18	30.16
	12:30 P.M.	"	30.15
	1:00 P.M.	0.19	30.14
	1:30 P.M.	0.18	30.12
	2:00 P.M.	"	30.10
	2:30 P.M.	"	30.09
	3:00 P.M.	0.17	30.08
	3:30 P.M.	0.18	30.07
	4:00 P.M.	"	30.05
	4:30 P.M.	"	30.04
	5:00 P.M.	"	30.03
	5:30 P.M.	"	30.02
	6:00 P.M.	0.19	30.00
	6:30 P.M.	0.18	29.99
	7:00 P.M.	0.17	29.98
	7:30 P.M.	0.18	29.97
	8:00 P.M.	"	29.96
	8:30 P.M.	"	29.95
	9:00 P.M.	"	29.94
	9:30 P.M.	"	29.93
	10:00 P.M.	"	29.91
	10:30 P.M.	"	29.90
	11:00 P.M.	"	29.89
	11:30 P.M.	"	29.88
12/14/69	12:00 M	"	29.87

TABLE 34 (Continued)

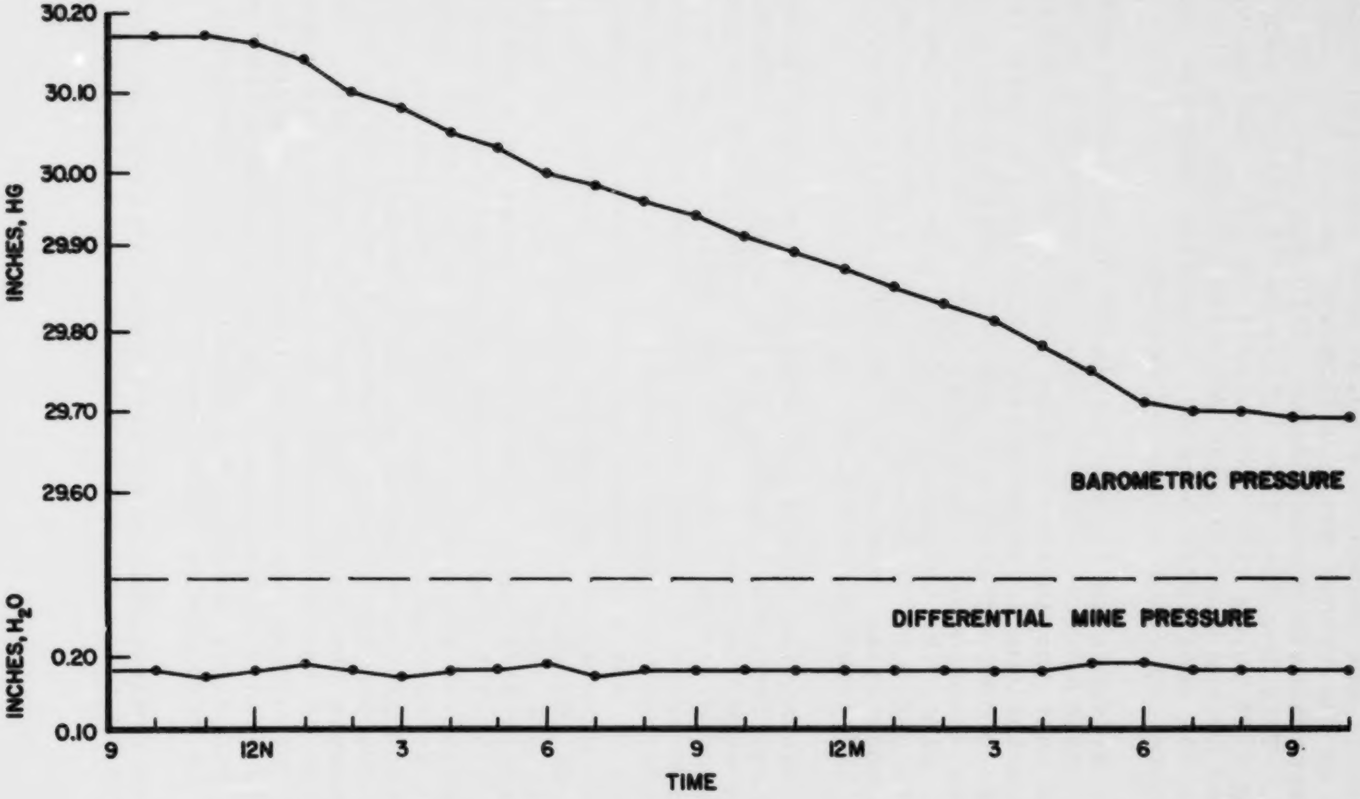
Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
12/14/69	12:30 A.M.	0.18	29.86
	1:00 A.M.	"	29.85
	1:30 A.M.	"	29.84
	2:00 A.M.	"	29.83
	2:30 A.M.	"	29.82
	3:00 A.M.	"	29.81
	3:30 A.M.	0.19	29.80
	4:00 A.M.	0.18	29.78
	4:30 A.M.	"	29.76
	5:00 A.M.	0.19	29.75
	5:30 A.M.	0.18	29.73
	6:00 A.M.	"	29.71
	6:30 A.M.	"	"
	7:00 A.M.	"	29.70
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	"	"
	9:00 A.M.	"	29.69
	9:30 A.M.	"	"
	10:00 A.M.	"	"
	10:30 A.M.	"	"
	11:00 A.M.	0.19	"
	11:30 A.M.	0.18	"
	12:00 N	"	"
	12:30 P.M.	"	"
	1:00 P.M.	"	"
	1:30 P.M.	0.19	"
	2:00 P.M.	0.18	"
	2:30 P.M.	"	"
	3:00 P.M.	"	29.70
	3:30 P.M.	"	"
	4:00 P.M.	"	"
			"

Additional leak detection studies were conducted using helium as the tracer gas. Helium was pumped into the mine at an approximate concentration of 10 ppm over a 20-hour period. This required five cylinders of helium, each containing 6.34 cu. m (224 cubic feet) of gas. Helium was detected by the portable gas detector within the first hour at the test hole; however, extensive searches could not locate any other points of leakage.

Several attempts to locate air leaks by infra-red photography proved unsuccessful. These tests were conducted on the premise that the infra-red film could detect relatively small variations in temperature. Photographs were taken with the blower operating at maximum capacity during periods when the atmospheric temperature was in the low and middle teens. Since the temperature of the mine was a constant 54°F, temperature differentials of up to 40°F were observed at the test hole; however, no anomalies could be detected in the infra-red photographs.

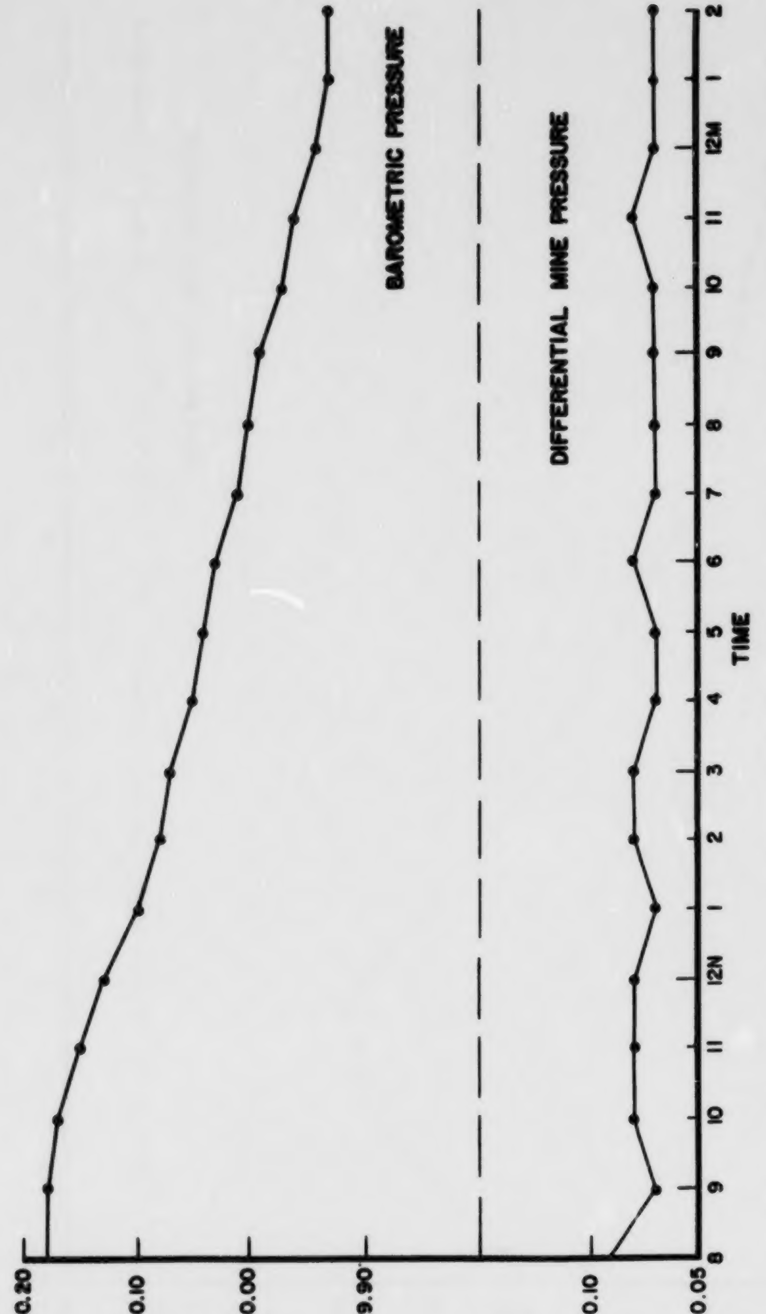
On the assumption that there were no other significant areas of leakage from the King No. 2 mine site, the pressurization studies were continued in order to investigate the results of reduced air flow rates. It was decided to reduce the air injection rates in steps until a differential pressure was obtained that was either affected by changes in barometric pressure or was the lowest positive differential pressure that could be maintained reliably. It appears that the latter is the case since it was possible to maintain pressures in the range of 0.10-0.15 cm (0.04"-0.06") water with little difficulty with air flow rates of 4.2-4.9 cu. m/minute (150-175 cfm). The data collected during the final pressurization studies is tabulated in Tables 35 through 49. Figures 26 through 31 illustrate the relationship between barometric pressure fronts and differential mine pressure at various pumping rates; apparently, there is no relationship between the two at this particular mine site. A summation of the significant pressurization test runs conducted throughout the course of this study appears in Table 50, and a comparison of the mine differential pressures before and after sealing the fracture zone previously discussed is graphically presented in Figure 32.

The mine pressurization studies were "shelved" in February, 1970, so that the sub-surface explorations discussed in



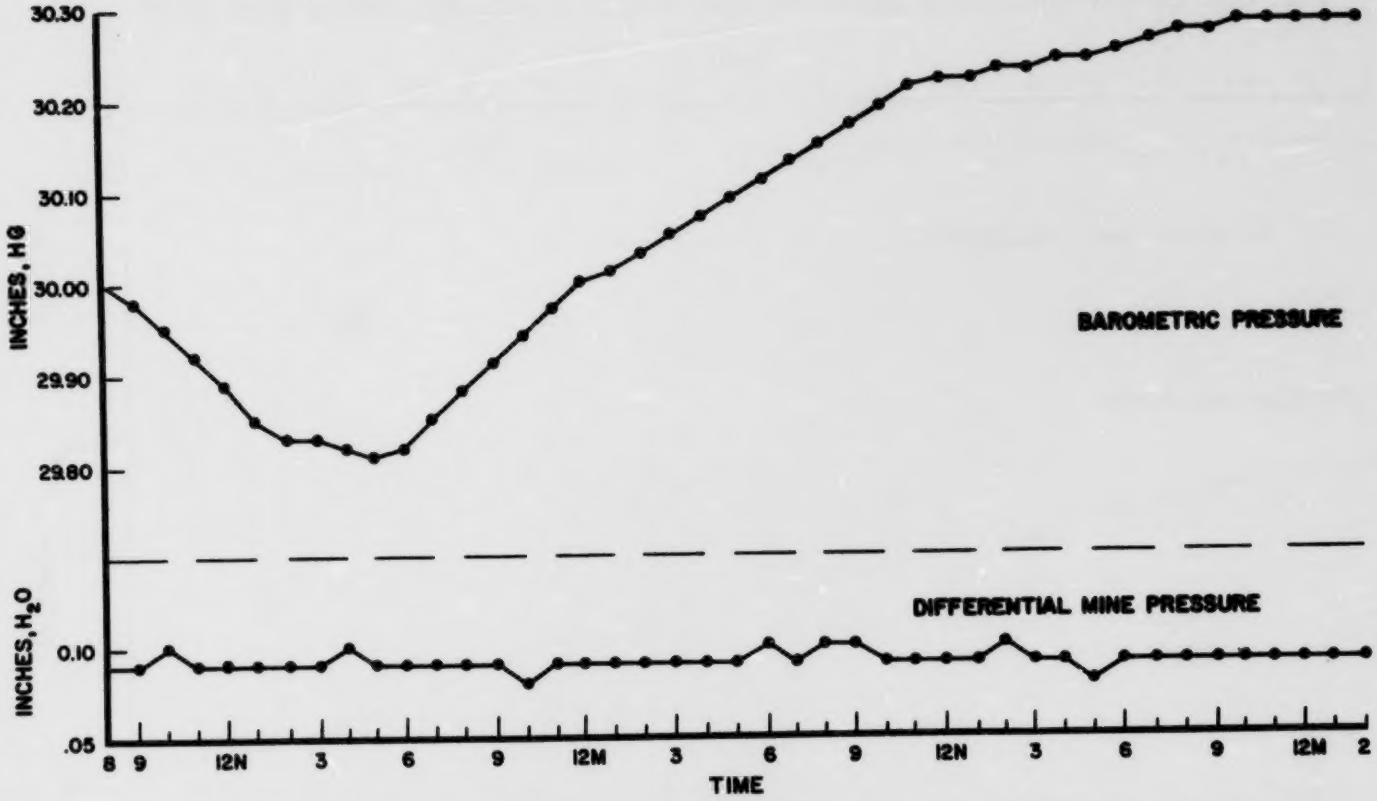
MINE PRESSURE VS. BAROMETRIC PRESSURE AT AIR FLOW RATE OF 540 CFM
KING NO.2 MINE SITE, DECEMBER 13 & 14, 1969

FIGURE 26



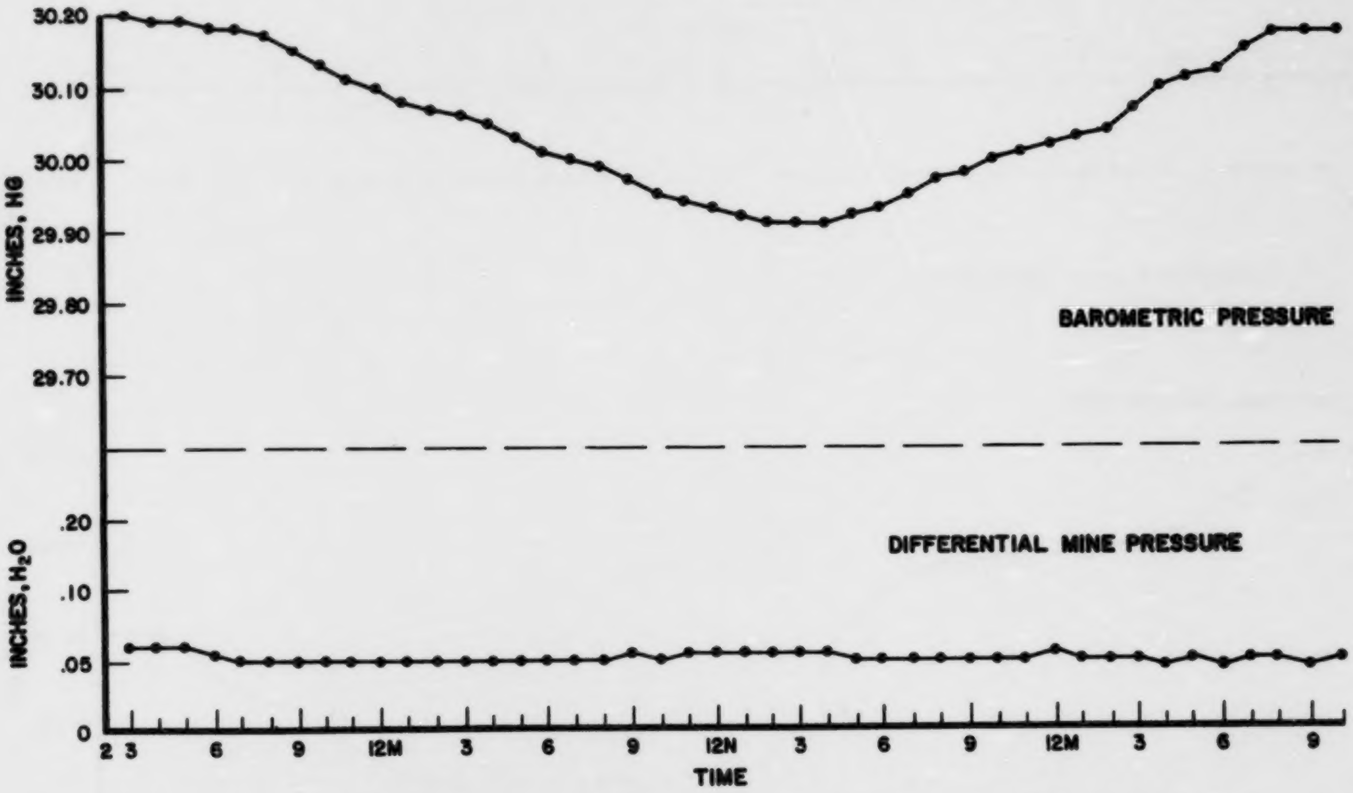
MINE PRESSURE VS. BAROMETRIC PRESSURE AT AIR FLOW RATE OF 280 CFM
KING NO. 2 MINE SITE, JANUARY 11 & 12, 1970

FIGURE 27



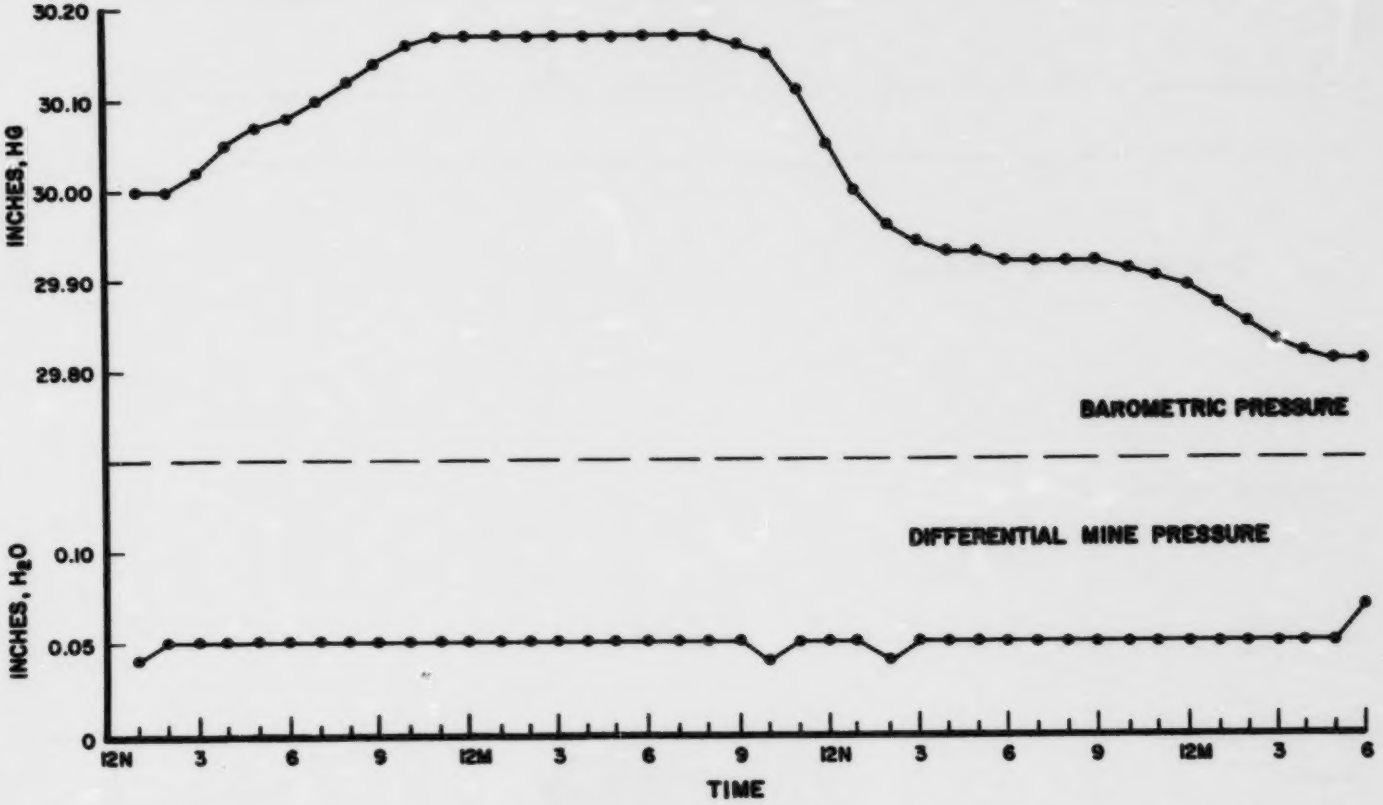
MINE PRESSURE VS. BAROMETRIC PRESSURE AT AIR FLOW RATE OF 240 CFM
KING NO.2 MINE SITE, JANUARY 20, 21 & 22, 1970

FIGURE 28



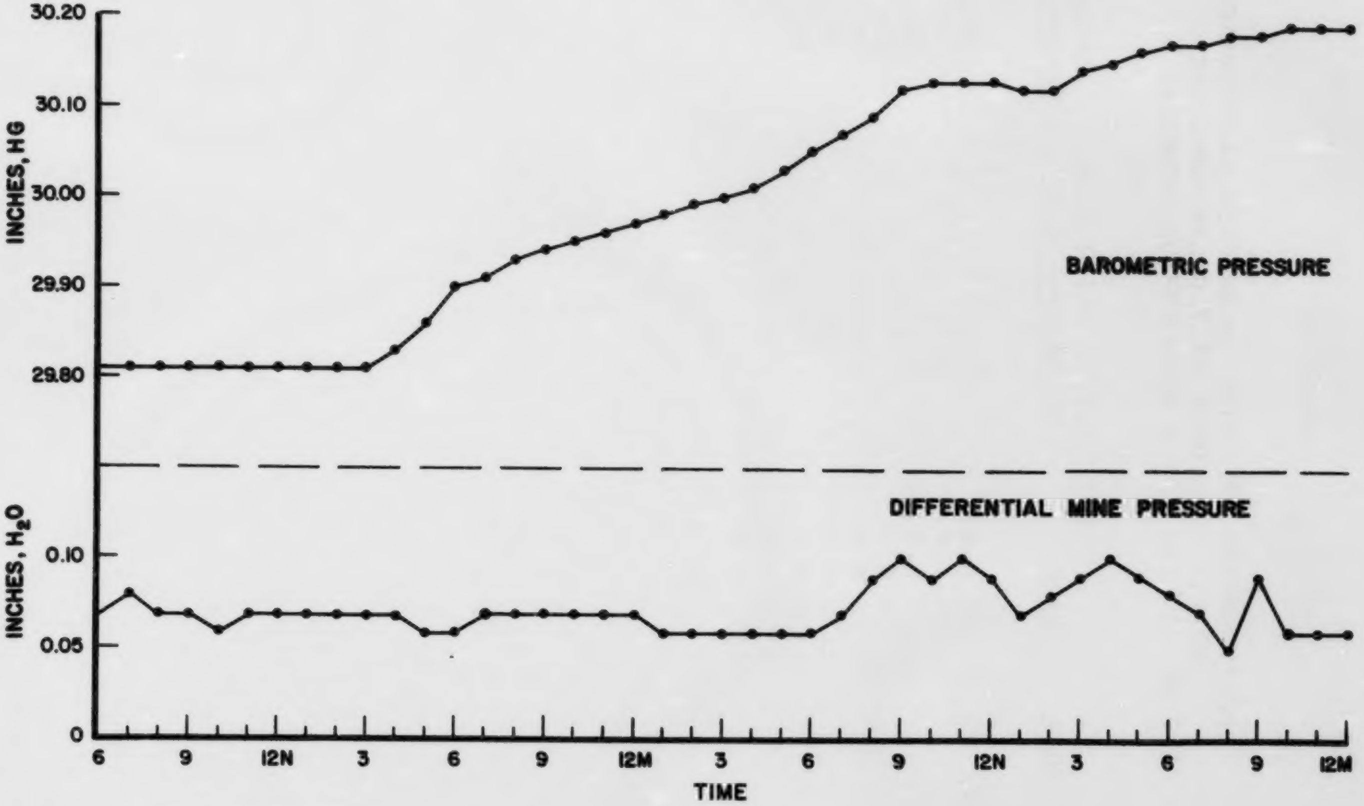
MINE PRESSURE VS. BAROMETRIC PRESSURE AT AIR FLOW RATE OF 160 CFM
KING NO. 2 MINE SITE, JANUARY 22 & 23, 1970

FIGURE 29



MINE PRESSURE VS. BAROMETRIC PRESSURE AT AIR FLOW RATE OF 160 CFM
KING NO. 2 MINE SITE, JANUARY 27, 28 & 29, 1970

FIGURE 30



MINE PRESSURE VS. BAROMETRIC PRESSURE AT AIR FLOW RATE OF 160 CFM
KING NO. 2 MINE SITE, JANUARY 29, 30 & 31, 1970

FIGURE 31

TABLE 35

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 710 CFM INTO THE KING NO. 2 MINE FOR 4 HOUR PERIOD, JANUARY 5, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/5/70	10:30 A.M.	0.23	30.33
	11:00 A.M.	0.24	"
	11:30 A.M.	0.23	30.31
	12:00 N	"	30.30
	12:30 P.M.	"	30.29
	1:00 P.M.	"	30.27
	1:30 P.M.	"	30.26
	2:00 P.M.	0.24	"
	2:30 P.M.	"	"

TABLE 36

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 500 CFM INTO THE KING NO. 2 MINE FOR 16 HOUR PERIOD, JANUARY 5-6, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/5/70	3:00 P.M.	0.15	30.25
	3:30 P.M.	0.13	"
	4:00 P.M.	"	"
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	0.14	"
	6:00 P.M.	0.13	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	0.14	30.24
	10:30 P.M.	0.13	"
	11:00 P.M.	"	30.23
	11:30 P.M.	"	"
1/6/70	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	30.22
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	0.14	30.21
	4:00 A.M.	0.13	"
	4:30 A.M.	"	"
	5:00 A.M.	0.14	30.20
	5:30 A.M.	0.13	"
	6:00 A.M.	"	30.19
	6:30 A.M.	"	"
	7:00 A.M.	"	"

TABLE 37

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1500 CFM INTO THE KING NO. 2 MINE FOR 8-1/2 HOUR PERIOD, JANUARY 6, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/6/70	7:30 A.M.	0.70	30.19
	8:00 A.M.	0.72	"
	8:30 A.M.	0.70	"
	9:00 A.M.	"	30.18
	9:30 A.M.	"	"
	10:00 A.M.	0.71	30.17
	10:30 A.M.	0.72	30.16
	11:00 A.M.	"	30.15
	11:30 A.M.	0.71	30.13
	12:00 N	"	"
	12:30 P.M.	"	30.12
	1:00 P.M.	0.70	30.10
	1:30 P.M.	"	30.08
	2:00 P.M.	"	30.05
	2:30 P.M.	"	30.03
	3:00 P.M.	0.71	30.02
	3:30 P.M.	0.70	30.01
	4:00 P.M.	"	30.00

TABLE 38

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 500 CFM INTO THE KING NO. 2 MINE FOR 7 HOUR PERIOD, JANUARY 8, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/8/70	9:00 A.M.	0.14	30.06
	9:30 A.M.	0.15	"
	10:00 A.M.	"	"
	10:30 A.M.	"	30.05
	11:00 A.M.	0.16	"
	11:30 A.M.	"	30.04
	12:00 N	0.15	30.03
	12:30 P.M.	"	"
	1:00 P.M.	0.16	30.02
	1:30 P.M.	"	"
	2:00 P.M.	"	30.01

TABLE 39

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 280 CFM INTO THE KING NO. 2 MINE FOR 95 HOUR PERIOD, JANUARY 8-12, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/8/70	2:30 P.M.	0.11	30.01
	3:00 P.M.	0.10	"
	3:30 P.M.	"	"
	4:00 P.M.	0.09	30.02
	4:30 P.M.	"	"
	5:00 P.M.	0.10	30.03
	5:30 P.M.	"	"
	6:00 P.M.	"	30.04
	6:30 P.M.	"	"
	7:00 P.M.	0.07	30.05
	7:30 P.M.	0.08	30.06
	8:00 P.M.	0.07	30.07
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	0.09	"
	10:00 P.M.	0.08	"
	10:30 P.M.	"	"
	11:00 P.M.	0.07	"
	11:30 P.M.	0.08	"
1/9/70	12:00 M	"	30.08
	12:30 A.M.	"	"
	1:00 A.M.	0.07	"
	1:30 A.M.	"	"
	2:00 A.M.	0.08	30.09
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	0.07	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	0.08	"
	6:30 A.M.	"	"
	7:00 A.M.	0.07	"
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	"	"
	9:00 A.M.	0.08	30.10
	9:30 A.M.	0.07	"

TABLE 39 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/9/70	10:00 A.M.	0.10	30.12
	10:30 A.M.	0.08	30.13
	11:00 A.M.	0.10	30.12
	11:30 A.M.	0.09	30.11
	12:00 N	0.08	30.10
	12:30 P.M.	0.10	"
	1:00 P.M.	0.07	"
	1:30 P.M.	"	"
	2:00 P.M.	0.08	"
	2:30 P.M.	0.09	30.11
	3:00 P.M.	0.08	"
	3:30 P.M.	0.07	"
	4:00 P.M.	0.08	30.12
	4:30 P.M.	"	"
	5:00 P.M.	"	30.13
	5:30 P.M.	"	30.14
	6:00 P.M.	0.09	30.15
	6:30 P.M.	0.08	30.16
	7:00 P.M.	"	30.17
	7:30 P.M.	0.07	"
	8:00 P.M.	0.08	30.18
	8:30 P.M.	"	"
	9:00 P.M.	"	30.19
	9:30 P.M.	"	"
	10:00 P.M.	0.07	"
	10:30 P.M.	0.08	"
	11:00 P.M.	"	"
	11:30 P.M.	0.09	"
1/10/70	12:00 M	0.08	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	0.07	30.20
	2:30 A.M.	"	"
	3:00 A.M.	"	30.21
	3:30 A.M.	0.09	"
	4:00 A.M.	0.08	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	30.22
	6:00 A.M.	0.07	"
	6:30 A.M.	0.08	"
	7:00 A.M.	0.07	30.23
	7:30 A.M.	"	"

TABLE 39 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/10/70	8:00 A.M.	0.08	30.23
	8:30 A.M.	0.07	"
	9:00 A.M.	"	30.24
	9:30 A.M.	0.08	"
	10:00 A.M.	"	30.25
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	"	"
	12:00 N	0.07	30.24
	12:30 P.M.	"	"
	1:00 P.M.	"	"
	1:30 P.M.	0.08	"
	2:00 P.M.	"	30.23
	2:30 P.M.	"	"
	3:00 P.M.	0.07	"
	3:30 P.M.	"	"
	4:00 P.M.	"	"
	4:30 P.M.	0.06	"
	5:00 P.M.	0.07	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	0.08	"
	8:00 P.M.	"	"
	8:30 P.M.	0.07	"
	9:00 P.M.	0.08	"
	9:30 P.M.	"	"
	10:00 P.M.	0.07	30.22
	10:30 P.M.	0.08	"
	11:00 P.M.	"	30.21
	11:30 P.M.	"	"
1/11/70	12:00 M	"	30.20
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	30.19
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	0.07	"
	4:00 A.M.	0.08	30.18

TABLE 39 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/11/70	4:30 A.M.	0.08	30.18
	5:00 A.M.	"	"
	5:30 A.M.	0.07	"
	6:00 A.M.	0.08	"
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M	"	"
	8:30 A.M.	"	"
	9:00 A.M.	0.07	"
	9:30 A.M.	0.08	"
	10:00 A.M.	"	30.17
	10:30 A.M.	"	30.16
	11:00 A.M.	"	30.15
	11:30 A.M.	"	30.14
	12:00 N	"	30.13
	12:30 P.M.	"	30.12
	1:00 P.M.	0.07	30.10
	1:30 P.M.	0.08	30.09
	2:00 P.M.	"	30.08
	2:30 P.M.	"	30.07
	3:00 P.M.	"	"
	3:30 P.M.	0.07	30.06
	4:00 P.M.	"	30.05
	4:30 P.M.	0.08	"
	5:00 P.M.	0.07	30.04
	5:30 P.M.	"	"
	6:00 P.M.	0.08	30.03
	6:30 P.M.	0.07	30.02
	7:00 P.M.	"	30.01
	7:30 P.M.	"	30.00
	8:00 P.M.	"	"
	8:30 P.M.	"	29.99
	9:00 P.M.	"	"
	9:30 P.M.	0.06	29.98
	10:00 P.M.	0.07	29.97
	10:30 P.M.	"	"
	11:00 P.M.	0.08	29.96
	11:30 P.M.	"	29.95
1/12/70	12:00 M	0.07	29.94
	12:30 A.M.	0.06	"

TABLE 39 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/12/70	1:00 A.M.	0.07	29.93
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	29.94
	4:30 A.M.	"	"
	5:00 A.M.	"	29.95
	5:30 A.M.	0.06	"
	6:00 A.M.	0.07	29.96
	6:30 A.M.	"	"
	7:00 A.M.	"	29.97
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	0.06	"
	9:00 A.M.	0.07	"
	9:30 A.M.	"	"
	10:00 A.M.	"	"
	10:30 A.M.	"	"
	11:00 A.M.	0.08	"
	11:30 A.M.	"	"
	12:00 N	"	"
	12:00 P.M.	"	"
	1:00 P.M.	"	"
	1:30 P.M.	0.07	"

TABLE 40

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 170 CFM INTO THE KING NO. 2 MINE FOR 42 HOUR PERIOD, JANUARY 12-14, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/12/70	2:00 P.M.	0.06	29.98
	2:30 P.M.	"	"
	3:00 P.M.	0.05	29.99
	3:30 P.M.	0.06	"
	4:00 P.M.	"	30.00
	4:30 P.M.	"	"
	5:00 P.M.	0.05	30.01
	5:30 P.M.	0.06	"
	6:00 P.M.	"	30.02
	6:30 P.M.	0.05	30.03
	7:00 P.M.	0.06	30.04
	7:30 P.M.	"	30.05
	8:00 P.M.	"	30.06
	8:30 P.M.	0.05	30.07
	9:00 P.M.	0.06	30.08
	9:30 P.M.	"	30.09
	10:00 P.M.	"	30.10
	10:30 P.M.	"	30.11
	11:00 P.M.	"	"
	11:30 P.M.	"	"
1/13/70	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	0.04	"
	2:00 A.M.	0.05	30.12
	2:30 A.M.	"	"
	3:00 A.M.	"	30.13
	3:30 A.M.	"	"
	4:00 A.M.	"	30.14
	4:30 A.M.	"	"
	5:00 A.M.	"	30.15
	5:30 A.M.	"	"
	6:00 A.M.	"	30.16
	6:30 A.M.	"	"
	7:00 A.M.	0.06	30.17
	7:30 A.M.	0.05	"
	8:00 A.M.	0.04	"

TABLE 40 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/13/70	8:30 A.M.	0.04	30.18
	9:00 A.M.	"	30.19
	9:30 A.M.	0.05	"
	10:00 A.M.	0.04	30.20
	10:30 A.M.	0.06	"
	11:00 A.M.	0.05	"
	11:30 A.M.	0.08	"
	12:00 N	0.07	30.19
	12:30 P.M.	0.05	"
	1:00 P.M.	0.08	30.18
	1:30 P.M.	0.05	"
	2:00 P.M.	0.00	30.17
	2:30 P.M.	0.05	"
	3:00 P.M.	0.07	30.18
	3:30 P.M.	0.06	"
	4:00 P.M.	0.05	"
	4:30 P.M.	0.07	"
	5:00 P.M.	"	"
	5:30 P.M.	0.06	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	30.19
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	0.05	"
	9:30 P.M.	0.04	"
	10:00 P.M.	0.06	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
1/14/70	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	0.05	"
	2:30 A.M.	0.06	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"

TABLE 40 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/14/70	5:30 A.M.	0.05	30.19
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	"	30.20
	7:30 A.M.	0.06	"
	8:00 A.M.	0.07	"
	8:30 A.M.	"	30.21

TABLE 41

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 300 CFM INTO THE KING NO. 2 MINE FOR 121-1/2 HOUR PERIOD, JANUARY 14-19, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/14/70	4:00 P.M.	0.11	30.19
	4:30 P.M.	"	"
	5:00 P.M.	0.10	"
	5:30 P.M.	"	30.18
	6:00 P.M.	0.11	"
	6:30 P.M.	0.10	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	0.11	"
	8:30 P.M.	0.10	"
	9:00 P.M.	"	"
	9:30 P.M.	0.11	"
	10:00 P.M.	0.10	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	30.19
1/15/70	12:00 M	"	"
	12:30 A.M.	0.11	"
	1:00 A.M.	0.10	30.20
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	30.21
	3:30 A.M.	"	"
	4:00 A.M.	0.09	30.22
	4:30 A.M.	0.10	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	0.09	"
	9:00 A.M.	0.10	30.23
	9:30 A.M.	"	"

TABLE 41 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/15/70	10:00 A.M.	0.10	30.24
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	"	"
	12:00 N	"	"
	12:30 P.M.	0.09	30.23
	1:00 P.M.	0.10	30.22
	1:30 P.M.	"	30.21
	2:00 P.M.	"	30.20
	2:30 P.M.	0.11	"
	3:00 P.M.	0.10	30.19
	3:30 P.M.	"	"
	4:00 P.M.	"	"
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	0.11	"
	7:00 P.M.	"	"
	7:30 P.M.	0.10	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	0.09	"
	11:00 P.M.	0.10	30.20
	11:30 P.M.	"	"
1/16/70	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	0.09	"
	2:00 A.M.	0.10	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	0.11	"
	5:30 A.M.	0.10	"
			"

TABLE 41 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/16/70	6:00 A.M.	0.10	30.20
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	"	"
	9:00 A.M.	"	"
	9:30 A.M.	0.12	30.21
	10:00 A.M.	0.10	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	"	"
	12:00 N	"	30.20
	12:30 P.M.	0.09	"
	1:00 P.M.	0.10	30.19
	1:30 P.M.	"	30.18
	2:00 P.M.	"	30.17
	2:30 P.M.	"	30.15
	3:00 P.M.	"	30.13
	3:30 P.M.	"	30.12
	4:00 P.M.	"	30.11
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	30.12
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	30.11
	11:30 P.M.	0.11	"
1/17/70	12:00 M	0.10	"
	12:30 A.M.	"	"
	1:00 A.M.	"	30.10
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	0.11	"
	3:00 A.M.	0.10	30.09

TABLE 41 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/17/70	3:30 A.M.	0.10	30.09
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	30.08
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	0.11	30.07
	7:30 A.M.	0.10	"
	8:00 A.M.	"	"
	8:30 A.M.	"	"
	9:00 A.M.	"	30.06
	9:30 A.M.	"	"
	10:00 A.M.	"	30.05
	10:30 A.M.	"	"
	11:00 A.M.	0.11	30.04
	11:30 A.M.	"	"
	12:00 N	"	30.03
	12:30 P.M.	0.10	30.02
	1:00 P.M.	"	30.00
	1:30 P.M.	"	29.98
	2:00 P.M.	"	29.96
	2:30 P.M.	"	29.95
	3:00 P.M.	"	29.94
	3:30 P.M.	"	29.93
	4:00 P.M.	0.09	"
	4:30 P.M.	0.10	"
	5:00 P.M.	"	29.92
	5:30 P.M.	"	"
	6:00 P.M.	"	29.91
	6:30 P.M.	0.09	"
	7:00 P.M.	0.10	"
	7:30 P.M.	"	"
	8:00 P.M.	"	29.90
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	0.09	"
	10:00 P.M.	0.10	29.89
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"

TABLE 41 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/18/70	12:00 M	0.10	29.88
	12:30 A.M.	"	29.87
	1:00 A.M.	"	29.86
	1:30 A.M.	0.09	"
	2:00 A.M.	0.10	29.85
	2:30 A.M.	"	"
	3:00 A.M.	0.11	"
	3:30 A.M.	0.10	"
	4:00 A.M.	"	29.84
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	"	29.83
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	0.09	"
	8:00 A.M.	0.10	"
	8:30 A.M.	"	"
	9:00 A.M.	"	"
	9:30 A.M.	0.09	"
	10:00 A.M.	0.10	"
	10:30 A.M.	0.11	"
	11:00 A.M.	0.10	29.84
	11:30 A.M.	"	"
	12:00 N	0.09	29.85
	12:30 P.M.	"	29.86
	1:00 P.M.	0.10	29.87
	1:30 P.M.	"	29.88
	2:00 P.M.	"	"
	2:30 P.M.	"	"
	3:00 P.M.	"	"
	3:30 P.M.	0.11	"
	4:00 P.M.	0.10	"
	4:30 P.M.	"	29.89
	5:00 P.M.	"	29.90
	5:30 P.M.	"	"
	6:00 P.M.	0.09	29.91
	6:30 P.M.	0.10	29.92
	7:00 P.M.	"	29.93
	7:30 P.M.	"	29.94
	8:00 P.M.	"	"
	8:30 P.M.	"	29.95
	9:00 P.M.	"	"

TABLE 41 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/18/70	9:30 P.M.	0.11	29.96
	10:00 P.M.	0.10	29.97
	10:30 P.M.	"	"
	11:00 P.M.	"	29.98
	11:30 P.M.	"	"
1/19/70	12:00 M	"	29.99
	12:30 A.M.	"	"
	1:00 A.M.	0.09	30.00
	1:30 A.M.	"	"
	2:00 A.M.	0.10	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	0.11	30.01
	4:30 A.M.	0.10	"
	5:00 A.M.	"	30.02
	5:30 A.M.	"	"
	6:00 A.M.	"	30.03
	6:30 A.M.	"	"
	7:00 A.M.	0.11	30.04
	7:30 A.M.	0.10	"
	8:00 A.M.	0.11	30.05
	8:30 A.M.	0.10	"
	9:00 A.M.	"	"
	9:30 A.M.	"	"
	10:00 A.M.	0.09	"
	10:30 A.M.	0.10	"
	11:00 A.M.	0.09	30.04
	11:30 A.M.	0.10	"
	12:00 N	0.11	30.03
	12:30 P.M.	0.10	30.02
	1:00 P.M.	"	30.01
	1:30 P.M.	"	"
	2:00 P.M.	"	"
	2:30 P.M.	0.09	30.02
	3:00 P.M.	0.10	"
	3:30 P.M.	"	"
	4:00 P.M.	"	30.03
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"

TABLE 42

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 240 CFM INTO THE KING NO. 2 MINE FOR 63 HOUR PERIOD, JANUARY 19-22, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/19/70	6:00 P.M.	0.09	30.04
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	30.05
	8:30 P.M.	"	"
	9:00 P.M.	"	30.06
	9:30 P.M.	0.07	"
	10:00 P.M.	0.09	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
1/20/70	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	30.05
	3:30 A.M.	0.10	"
	4:00 A.M.	0.09	30.04
	4:30 A.M.	"	"
	5:00 A.M.	"	30.03
	5:30 A.M.	0.10	30.02
	6:00 A.M.	0.09	30.01
	6:30 A.M.	0.10	"
	7:00 A.M.	0.09	"
	7:30 A.M.	"	"
	8:00 A.M.	"	30.00
	8:30 A.M.	"	29.99
	9:00 A.M.	"	29.98
	9:30 A.M.	"	29.97
	10:00 A.M.	0.10	29.95
	10:30 A.M.	"	29.93
	11:00 A.M.	0.09	29.92
	11:30 A.M.	"	29.90
	12:00 N	"	29.89

TABLE 42 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/20/70	12:30 P.M.	0.09	29.87
	1:00 P.M.	"	29.85
	1:30 P.M.	0.08	29.84
	2:00 P.M.	0.09	29.83
	2:30 P.M.	"	"
	3:00 P.M.	"	"
	3:30 P.M.	"	"
	4:00 P.M.	0.10	29.82
	4:30 P.M.	0.09	"
	5:00 P.M.	"	29.81
	5:30 P.M.	"	"
	6:00 P.M.	"	29.82
	6:30 P.M.	"	29.83
	7:00 P.M.	"	29.85
	7:30 P.M.	0.08	29.86
	8:00 P.M.	0.09	29.88
	8:30 P.M.	"	29.90
	9:00 P.M.	"	29.91
	9:30 P.M.	0.08	29.92
	10:00 P.M.	"	29.94
	10:30 P.M.	0.09	29.96
	11:00 P.M.	"	29.97
	11:30 P.M.	"	29.98
1/21/70	12:00 M	"	30.00
	12:30 A.M.	"	"
	1:00 A.M.	"	30.01
	1:30 A.M.	"	30.02
	2:00 A.M.	"	30.03
	2:30 A.M.	"	30.04
	3:00 A.M.	"	30.05
	3:30 A.M.	0.10	30.06
	4:00 A.M.	0.09	30.07
	4:30 A.M.	"	30.08
	5:00 A.M.	"	30.09
	5:30 A.M.	"	30.10
	6:00 A.M.	0.10	30.11
	6:30 A.M.	0.09	30.12
	7:00 A.M.	"	30.13
	7:30 A.M.	"	30.14

TABLE 42 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/21/70	8:00 A.M.	0.10	30.15
	8:30 A.M.	0.09	30.16
	9:00 A.M.	0.10	30.17
	9:30 A.M.	"	30.18
	10:00 A.M.	0.09	30.19
	10:30 A.M.	0.08	30.20
	11:00 A.M.	0.09	30.21
	11:30 A.M.	"	30.22
	12:00 N	"	"
	12:30 P.M.	"	"
	1:00 P.M.	"	"
	1:30 P.M.	"	"
	2:00 P.M.	0.10	30.23
	2:30 P.M.	0.09	"
	3:00 P.M.	"	"
	3:30 P.M.	"	"
	4:00 P.M.	"	30.24
	4:30 P.M.	"	"
	5:00 P.M.	0.08	"
	5:30 P.M.	0.09	"
	6:00 P.M.	"	30.25
	6:30 P.M.	"	"
	7:00 P.M.	"	30.26
	7:30 P.M.	"	"
	8:00 P.M.	"	30.27
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	30.28
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
1/22/70	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"

TABLE 42 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/22/70	5:00 A.M.	0.09	30.28
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	"	30.29
	7:30 A.M.	"	"
	8:00 A.M.	"	"
	8:30 A.M.	"	"
	9:00 A.M.	0.10	"

TABLE 43

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 1830 CFM INTO THE KING NO. 2 MINE FOR 4 HOUR PERIOD, JANUARY 22, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/22/70	9:30 A.M.	1.02	30.29
	10:00 A.M.	"	30.30
	10:30 A.M.	"	"
	11:00 A.M.	"	30.29
	11:30 A.M.	"	"
	12:00 N	"	30.28
	12:30 P.M.	1.00	30.27
	1:00 P.M.	1.02	30.25
	1:30 P.M.	"	30.23

TABLE 44

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 160 CFM INTO THE KING NO. 2 MINE FOR 234 HOUR PERIOD, JANUARY 22 - FEBRUARY 1, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/22/70	2:00 P.M.	0.20	30.21
	2:30 P.M.	0.09	"
	3:00 P.M.	0.07	30.20
	3:30 P.M.	"	"
	4:00 P.M.	"	30.19
	4:30 P.M.	0.06	"
	5:00 P.M.	0.07	"
	5:30 P.M.	0.06	"
	6:00 P.M.	"	30.18
	6:30 P.M.	0.05	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	30.17
	8:30 P.M.	"	30.16
	9:00 P.M.	"	30.15
	9:30 P.M.	"	30.14
	10:00 P.M.	"	30.13
	10:30 P.M.	"	30.12
	11:00 P.M.	"	30.11
	11:30 P.M.	"	"
1/23/70	12:00 M	"	30.10
	12:30 A.M.	"	30.09
	1:00 A.M.	"	30.08
	1:30 A.M.	"	"
	2:00 A.M.	"	30.07
	2:30 A.M.	"	"
	3:00 A.M.	"	30.06
	3:30 A.M.	"	"
	4:00 A.M.	"	30.05
	4:30 A.M.	"	30.04
	5:00 A.M.	"	30.03
	5:30 A.M.	"	30.02
	6:00 A.M.	"	30.01
	6:30 A.M.	"	"
	7:00 A.M.	"	30.00
	7:30 A.M.	"	"

TABLE 44 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/23/70	8:00 A.M.	0.05	29.99
	8:30 A.M.	0.06	29.98
	9:00 A.M.	"	29.97
	9:30 A.M.	0.05	29.96
	10:00 A.M.	"	29.95
	10:30 A.M.	0.07	"
	11:00 A.M.	0.06	9.94
	11:30 A.M.	"	"
	12:00 N	"	29.93
	12:30 P.M.	0.07	"
	1:00 P.M.	0.06	29.92
	1:30 P.M.	0.07	"
	2:00 P.M.	0.06	29.91
	2:30 P.M.	0.07	"
	3:00 P.M.	0.06	"
	3:30 P.M.	0.05	"
	4:00 P.M.	0.06	"
	4:30 P.M.	0.05	"
	5:00 P.M.	"	29.92
	5:30 P.M.	"	"
	6:00 P.M.	"	29.92
	6:30 P.M.	"	29.94
	7:00 P.M.	0.06	29.95
	7:30 P.M.	0.05	29.96
	8:00 P.M.	"	29.97
	8:30 P.M.	"	"
	9:00 P.M.	"	29.98
	9:30 P.M.	"	29.99
	10:00 P.M.	"	30.00
	10:30 P.M.	0.06	"
	11:00 P.M.	0.05	30.01
	11:30 P.M.	"	"
1/24/70	12:00 M	0.06	30.02
	12:30 A.M.	0.05	"
	1:00 A.M.	"	30.03
	1:30 A.M.	"	"
	2:00 A.M.	"	30.04
	2:30 A.M.	"	30.05
	3:00 A.M.	"	30.07
	3:30 A.M.	0.04	30.09

TABLE 44 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/24/70	4:00 A.M.	0.04	30.10
	4:30 A.M.	0.05	"
	5:00 A.M.	"	30.11
	5:30 A.M.	"	"
	6:00 A.M.	0.04	30.12
	6:30 A.M.	0.05	30.14
	7:00 A.M.	"	30.15
	7:30 A.M.	"	30.16
	8:00 A.M.	"	30.17
	8:30 A.M.	"	"
	9:00 A.M.	0.04	"
	9:30 A.M.	0.05	"
	10:00 A.M.	"	"
	10:30 A.M.	0.04	"
	11:00 A.M.	0.05	"
	11:30 A.M.	0.06	"
	12:00 N	0.05	"
	12:30 P.M.	"	"
	1:00 P.M.	0.06	30.15
	1:30 P.M.	"	30.13
	2:00 P.M.	"	30.11
	2:30 P.M.	0.05	30.10
	3:00 P.M.	"	"
	3:30 P.M.	0.06	30.09
	4:00 P.M.	"	"
	4:30 P.M.	"	"
	5:00 P.M.	0.07	"
	5:30 P.M.	0.05	"
	6:00 P.M.	0.06	"
	6:30 P.M.	0.05	30.08
	7:00 P.M.	"	30.07
	7:30 P.M.	"	30.06
	8:00 P.M.	"	30.05
	8:30 P.M.	"	"
	9:00 P.M.	"	30.04
	9:30 P.M.	0.06	"
	10:00 P.M.	0.05	30.03
	10:30 P.M.	"	"
	11:00 P.M.	"	30.02
	11:30 P.M.	"	"

TABLE 44 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/25/70	12:00 M	0.04	30.01
	12:30 A.M.	0.05	30.00
	1:00 A.M.	"	29.99
	1:30 A.M.	"	29.98
	2:00 A.M.		29.97
	2:30 A.M.	0.05	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	0.04	29.96
	4:30 A.M.	0.05	"
	5:00 A.M.	"	29.95
	5:30 A.M.	"	"
	6:00 A.M.	"	29.94
	6:30 A.M.	"	"
	7:00 A.M.	"	29.93
	7:30 A.M.	"	"
	8:00 A.M.	"	29.92
	8:30 A.M.	0.06	29.91
	9:00 A.M.	0.05	29.90
	9:30 A.M.	"	29.89
	10:00 A.M.	0.06	29.88
	10:30 A.M.	"	29.87
	11:00 A.M.	"	29.86
	11:30 A.M.	"	29.85
	12:00 N	"	29.84
	12:30 P.M.	"	29.83
	1:00 P.M.	"	29.81
	1:30 P.M.	"	29.79
	2:00 P.M.	"	29.78
	2:30 P.M.	"	"
	3:00 P.M.	0.05	29.77
	3:30 P.M.	"	"
	4:00 P.M.	"	29.76
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	0.06	"
	6:00 P.M.	"	29.75
	6:30 P.M.	0.05	29.74
	7:00 P.M.	"	29.73

TABLE 44 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/25/70	7:30 P.M.	0.05	29.73
	8:00 P.M.	"	29.72
	8:30 P.M.	0.06	"
	9:00 P.M.	"	29.71
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
1/26/70	12:00 M	"	"
	12:30 A.M.	0.05	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	0.06	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	0.05	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	"	29.72
	6:30 A.M.	"	"
	7:00 A.M.	"	29.73
	7:30 A.M.	"	29.74
	8:00 A.M.	"	29.75
1/27/70	1:00 P.M.	0.04	30.00
	1:30 P.M.	0.05	"
	2:00 P.M.	"	"
	2:30 P.M.	"	30.01
	3:00 P.M.	"	30.02
	3:30 P.M.	"	30.04
	4:00 P.M.	"	30.05
	4:30 P.M.	"	30.06
	5:00 P.M.	"	30.07
	5:30 P.M.	"	"
	6:00 P.M.	"	30.08
	6:30 P.M.	"	30.09
	7:00 P.M.	"	30.10
	7:30 P.M.	"	30.11
	8:00 P.M.	"	30.12
	8:30 P.M.	"	30.13

TABLE 44 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/27/70	9:00 P.M.	0.05	30.14
	9:30 P.M.	"	30.15
	10:00 P.M.	"	30.16
	10:30 P.M.	"	30.17
	11:00 P.M.	"	"
	11:30 P.M.	"	"
1/28/70	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	0.06	"
	2:00 A.M.	0.05	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	0.04	"
	6:00 A.M.	0.05	"
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	0.04	"
	8:00 A.M.	0.05	"
	8:30 A.M.	"	"
	9:00 A.M.	"	30.16
	9:30 A.M.	"	"
	10:00 A.M.	0.04	30.15
	10:30 A.M.	0.05	30.13
	11:00 A.M.	"	30.11
	11:30 A.M.	"	30.08
	12:00 N	"	30.05
	12:30 P.M.	"	30.02
	1:00 P.M.	"	30.00
	1:30 P.M.	0.04	29.98
	2:00 P.M.	"	29.96
	2:30 P.M.	0.05	29.95
	3:00 P.M.	"	29.94
	3:30 P.M.	0.04	"

TABLE 44 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/28/70	4:00 P.M.	0.05	29.93
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	29.92
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	29.91
	10:00 P.M.	"	"
	10:30 P.M.	"	"
	11:00 P.M.	"	29.90
	11:30 P.M.	"	"
1/29/70	12:00 M	"	29.89
	12:30 A.M.	"	29.88
	1:00 A.M.	"	29.87
	1:30 A.M.	"	29.86
	2:00 A.M.	"	29.85
	2:30 A.M.	"	29.84
	3:00 A.M.	"	29.83
	3:30 A.M.	"	29.82
	4:00 A.M.	"	"
	4:30 A.M.	0.06	"
	5:00 A.M.	0.05	29.81
	5:30 A.M.	"	"
	6:00 A.M.	0.07	"
	6:30 A.M.	0.08	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	0.07	"
	8:30 A.M.	"	"
	9:00 A.M.	"	"
	9:30 A.M.	"	"
	10:00 A.M.	0.06	"
	10:30 A.M.	0.05	"
	11:00 A.M.	0.07	"
	11:30 A.M.	0.06	"
	12:00 N	0.07	"

TABLE 44 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/29/70	12:30 P.M.	0.07	29.81
	1:00 P.M.	"	"
	1:30 P.M.	"	"
	2:00 P.M.	"	"
	2:30 P.M.	"	"
	3:00 P.M.	"	"
	3:30 P.M.	"	29.82
	4:00 P.M.	"	29.83
	4:30 P.M.	0.06	29.85
	5:00 P.M.	"	29.86
	5:30 P.M.	"	29.88
	6:00 P.M.	"	29.90
	6:30 P.M.	0.07	29.91
	7:00 P.M.	"	"
	7:30 P.M.	"	29.92
	8:00 P.M.	"	29.93
	8:30 P.M.	"	"
	9:00 P.M.	"	29.94
	9:30 P.M.	"	"
	10:00 P.M.	"	29.95
	10:30 P.M.	"	"
	11:00 P.M.	"	29.96
	11:30 P.M.	"	"
1/30/70	12:00 M	"	29.97
	12:30 A.M.	0.06	"
	1:00 A.M.	"	29.98
	1:30 A.M.	"	"
	2:00 A.M.	"	29.99
	2:30 A.M.	"	"
	3:00 A.M.	"	30.00
	3:30 A.M.	0.05	"
	4:00 A.M.	0.06	30.01
	4:30 A.M.	"	30.02
	5:00 A.M.	"	30.03
	5:30 A.M.	0.05	30.04
	6:00 A.M.	0.06	30.05
	6:30 A.M.	0.07	30.06
	7:00 A.M.	"	30.07
	7:30 A.M.	0.08	30.08
	8:00 A.M.	0.09	30.09
	8:30 A.M.	"	30.10
	9:00 A.M.	0.10	30.12

TABLE 44 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/30/70	9:30 A.M.	0.09	30.13
	10:00 A.M.	"	"
	10:30 A.M.	0.06	"
	11:00 A.M.	0.10	"
	11:30 A.M.	0.09	"
	12:00 N	"	"
	12:30 P.M.	"	30.12
	1:00 P.M.	0.07	"
	1:30 P.M.	0.11	"
	2:00 P.M.	0.08	"
	2:30 P.M.	0.05	30.13
	3:00 P.M.	0.09	30.14
	3:30 P.M.	0.07	"
	4:00 P.M.	0.10	30.15
	4:30 P.M.	0.09	"
	5:00 P.M.	"	30.16
	5:30 P.M.	0.08	"
	6:00 P.M.	"	30.17
	6:30 P.M.	0.07	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	0.05	30.18
	8:30 P.M.	0.06	"
	9:00 P.M.	0.07	"
	9:30 P.M.	0.05	"
	10:00 P.M.	0.06	30.19
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
1/31/70	12:00 M	"	"
	12:30 A.M.	0.05	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	0.06	"
	2:30 A.M.	"	"
	3:00 A.M.	"	30.20
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	0.05	"
	5:00 A.M.	0.06	"
	5:30 A.M.	0.05	"
	6:00 A.M.	0.06	"

TABLE 44 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
1/31/70	6:30 A.M.	0.06	30.20
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	0.05	"
	8:30 A.M.	0.06	"
	9:00 A.M.	0.05	"
	9:30 A.M.	0.06	"
	10:00 A.M.	"	"
	10:30 A.M.	"	"
	11:00 A.M.	"	"
	11:30 A.M.	"	30.19
	12:00 N	"	"
	12:30 P.M.	"	30.18
	1:00 P.M.	0.08	"
	1:30 P.M.	"	30.17
	2:00 P.M.	0.10	30.16
	2:30 P.M.	0.08	"
	3:00 P.M.	"	30.15
	3:30 P.M.	"	"
	4:00 P.M.	"	30.14
	4:30 P.M.	0.06	"
	5:00 P.M.	0.08	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	0.07	"
	7:30 P.M.	"	"
	8:00 P.M.	"	30.15
	8:30 P.M.	0.08	"
	9:00 P.M.	0.07	"
	9:30 P.M.	0.05	"
	10:00 P.M.	0.07	"
	10:30 P.M.	0.06	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
2/1/70	12:00 M	"	"
	12:30 A.M.	0.05	"
	1:00 A.M.	0.06	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	0.07	"
	3:00 A.M.	0.06	"
	3:30 A.M.	"	"

TABLE 44 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
2/1/70	4:00 A.M.	0.06	30.15
	4:30 A.M.	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	0.05	"
	7:00 A.M.	0.06	"
	7:30 A.M.	"	"

TABLE 45

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 200 CFM INTO THE KING NO. 2 MINE FOR 7-1/2 HOUR PERIOD, FEBRUARY 2, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
2/2/70	10:00 A.M.	0.10	29.67
	10:30 A.M.	0.09	29.65
	11:00 A.M.	"	29.63
	11:30 A.M.	"	29.62
	12:00 N	0.08	29.61
	12:30 P.M.	"	"
	1:00 P.M.	0.09	"
	1:30 P.M.	0.08	"
	2:00 P.M.	"	"
	2:30 P.M.	"	"
	3:00 P.M.	"	"
	3:30 P.M.	0.07	"
	4:00 P.M.	0.08	"
	4:30 P.M.	"	29.62
	5:00 P.M.	0.09	"
	5:30 P.M.	0.08	"

TABLE 46

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 440 CFM INTO THE KING NO. 2 MINE FOR 59 HOUR PERIOD, FEBRUARY 9-12, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
2/9/70	2:00 P.M.	0.16	30.03
	2:30 P.M.	"	"
	3:00 P.M.	"	"
	3:30 P.M.	"	"
	4:00 P.M.	"	"
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	0.15	"
	6:00 P.M.	0.16	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	0.15	30.02
	9:00 P.M.	"	"
	9:30 P.M.	"	30.01
	10:00 P.M.	"	30.00
	10:30 P.M.	"	29.99
	11:00 P.M.	"	29.97
	11:30 P.M.	"	29.96
2/10/70	12:00 M	0.13	29.95
	12:30 A.M.	0.14	"
	1:00 A.M.	0.11	"
	1:30 A.M.	0.14	"
	2:00 A.M.	"	29.94
	2:30 A.M.	0.13	29.93
	3:00 A.M.	0.14	29.92
	3:30 A.M.	"	29.91
	4:00 A.M	"	29.90
	4:30 A.M	"	"
	5:00 A.M.	"	"
	5:30 A.M.	"	29.89
	6:00 A.M.	"	"
	6:30 A.M.	0.12	"
	7:00 A.M.	0.14	"
	7:30 A.M.	"	29.88
	8:00 A.M.	"	"

TABLE 46 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
2/10/70	8:30 A.M.	0.12	29.88
	9:00 A.M.	0.14	"
	9:30 A.M.	0.11	"
	10:00 A.M.	0.14	29.87
	10:30 A.M.	0.11	"
	11:00 A.M.	0.13	29.86
	11:30 A.M.	"	"
	12:00 N	"	29.85
	12:30 P.M.	"	"
	1:00 P.M.	"	29.84
	1:30 P.M.	"	"
	2:00 P.M.	"	29.83
	2:30 P.M.	"	"
	3:00 P.M.	"	29.82
	3:30 P.M.	"	"
	4:00 P.M.	"	29.81
	4:30 P.M.	"	"
	5:00 P.M.	"	29.80
	5:30 P.M.	"	"
	6:00 P.M.	"	29.79
	6:30 P.M.	0.14	"
	7:00 P.M.	0.13	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	"
	10:30 P.M.	0.12	"
	11:00 P.M.	0.13	"
	11:30 P.M.	"	"
2/11/70	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	"

TABLE 46 (Continued)

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
2/11/70	5:30 A.M.	0.13	29.79
	6:00 A.M.	"	"
	6:30 A.M.	"	"
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	29.80
	8:30 A.M	"	"
	9:00 A.M.	0.12	"
	9:30 A.M.	"	"
	10:00 A.M.	"	29.81
	10:30 A.M.	"	"
	11:00 A.M.	0.10	29.82
	11:30 A.M.	0.12	"
	12:00 N	"	29.73
	12:30 P.M.	"	"
	1:00 P.M.	"	"
	1:30 P.M.	"	"
	2:00 P.M.	"	"
	2:30 P.M.	"	"
	3:00 P.M.	0.11	"
	3:30 P.M.	0.10	"
	4:00 P.M.	0.12	"
	4:30 P.M.	"	"
	5:00 P.M.	0.10	29.84
	5:30 P.M.	0.12	"
	6:00 P.M.	"	29.85
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	0.11	"
	8:00 P.M.	"	29.86
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	29.87
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
2/12/70	12:00 M	"	"
	12:30 A.M.	"	"
	1:00 A.M.	"	"

TABLE 47

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 350 CFM INTO THE KING NO. 2 MINE FOR 9 HOUR PERIOD, FEBRUARY 17-18, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
2/17/70	3:00 P.M.	0.10	30.02
	3:30 P.M.	"	30.05
	4:00 P.M.	"	30.07
	4:30 P.M.	"	"
	5:00 P.M.	"	"
	5:30 P.M.	"	"
	6:00 P.M.	"	"
	6:30 P.M.	"	"
	7:00 P.M.	"	"
	7:30 P.M.	"	"
	8:00 P.M.	"	"
	8:30 P.M.	"	"
	9:00 P.M.	"	"
	9:30 P.M.	"	"
	10:00 P.M.	"	30.08
	10:30 P.M.	"	"
	11:00 P.M.	"	"
	11:30 P.M.	"	"
2/18/70	12:00 M	"	30.07

TABLE 48

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 51 CFM INTO THE KING NO. 2 MINE FOR 7-1/2 HOUR PERIOD, FEBRUARY 18, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
2/18/70	12:30 A.M.	0.0	30.07
	1:00 A.M.	"	"
	1:30 A.M.	"	"
	2:00 A.M.	"	"
	2:30 A.M.	"	"
	3:00 A.M.	"	"
	3:30 A.M.	"	"
	4:00 A.M.	"	"
	4:30 A.M.	"	"
	5:00 A.M.	"	30.06
	5:30 A.M.	"	"
	6:00 A.M.	"	"
	6:30 A.M.	"	30.05
	7:00 A.M.	"	"
	7:30 A.M.	"	"
	8:00 A.M.	"	30.04

TABLE 49

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT AIR FLOW RATE OF 318 CFM INTO THE KING NO. 2 MINE FOR 5-1/2 HOUR PERIOD, FEBRUARY 18, 1970

Date	Time	Differential Mine Pressure, "H_2O	Barometric Pressure, "Hg.
2/18/70	10:00 A.M.	0.09	29.98
	10:30 A.M.	"	29.97
	11:00 A.M.	0.08	29.95
	11:30 A.M.	"	29.94
	12:00 N	0.09	29.93
	12:30 P.M.	0.10	29.91
	1:00 P.M.	"	29.89
	1:30 P.M.	0.09	29.87
	2:00 P.M.	"	29.85
	2:30 P.M.	"	29.83
	3:00 P.M.	0.10	29.81
	3:30 P.M.	0.09	29.80

TABLE 50

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT VARIOUS AIR FLOW RATES AND BAROMETRIC PRESSURES

TIME PERIOD		AIR INJECTION RATE (CFM)	DIFFERENTIAL MINE PRESSURE (" H_2O)			BAROMETRIC PRESSURE (" Hg)		
FROM	TO		AVERAGE	MAXIMUM	MINIMUM	HIGH	LOW	TREND
9:00AM 12/12/68	8:00PM 12/12/68	490	.04	.05	.03	30.53	30.41	Cyclic
3:15PM 12/23/68	11:30AM 12/24/68	575	.12	.28	.01	30.20	29.96	Rising
2:00PM 4/20/69	10:30AM 4/22/69	1900	.40	.41	.39	30.12	29.74	Falling
11:00AM 4/22/69	4:00PM 4/23/69	1780	.35	.38	.30	29.77	29.71	Cyclic
10:30AM 5/1/69	5:30PM 5/1/69	1580	.27	.30	.29	30.22	30.18	Falling
12:00N 5/2/69	5:00PM 5/2/69	2000	.40	.42	.38	30.21	30.14	Falling
10:30AM 5/6/69	10:30AM 5/7/69	960	.14	.15	.13	30.05	30.00	Steady
11:00AM 5/7/69	10:30AM 5/8/69	1200	.18	.20	.17	30.06	29.99	Falling
11:00AM 5/8/69	10:30AM 5/9/69	1400	.22	.25	.19	29.98	29.64	Falling

TABLE 50 (continued)

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT VARIOUS AIR FLOW RATES AND BAROMETRIC PRESSURES

TIME PERIOD		AIR INJECTION RATE (CFM)	DIFFERENTIAL MINE PRESSURE (" H_2O)			BAROMETRIC PRESSURE (" Hg)		
FROM	TO		AVERAGE	MAXIMUM	MINIMUM	HIGH	LOW	TREND
11:00AM 5/9/69	4:30PM 5/9/69	1580	.30	.32	.27	29.64	29.64	Steady
9:00AM 5/14/69	10:30AM 5/15/69	1580	.28	.30	.27	30.22	30.14	Rising
11:00AM 5/15/69	4:00PM 5/15/69	1750	.31	.32	.31	30.22	30.17	Falling
10:30AM 5/16/69	4:00PM 5/16/69	1895	.36	.37	.36	30.21	30.12	Falling
10:00AM 5/19/69	2:30PM 5/21/69	1920	.37	.38	.35	30.22	30.00	Rising
1:30PM 5/22/69	9:00AM 5/23/69	1980	.37	.38	.36	30.16	30.16	Steady
9:30AM 5/23/69	4:00PM 5/23/69	1940	.37	.38	.37	30.17	30.12	Falling
1:30PM 5/27/69	6:00PM 5/29/69	1760	.30	.31	.29	30.27	29.98	Falling
9:00AM 8/4/69	8:00AM 8/5/69	1660	.31	.31	.29	30.05	30.05	Steady

TABLE 50 (continued)

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT VARIOUS AIR FLOW RATES AND BAROMETRIC PRESSURES

TIME PERIOD		AIR INJECTION RATE (CFM)	DIFFERENTIAL MINE PRESSURE (" H_2O)			BAROMETRIC PRESSURE (" Hg)		
FROM	TO		AVERAGE	MAXIMUM	MINIMUM	HIGH	LOW	TREND
9:30AM 9/10/69	10:30AM 9/11/69	1780	.30	.32	.29	30.19	30.19	Steady
11:00AM 9/11/69	3:00PM 9/15/69	1720	.30	.31	.28	30.20	30.20	Steady
10:00AM 9/18/69	5:00PM 9/18/69	900	.12	.12	.11	30.17	30.12	Falling
11:30AM 12/10/69	3:00PM 12/10/69	1940	.82	.85	.80	29.93	29.87	Falling
3:30PM 12/10/69	8:00PM 12/10/69	900	.37	.38	.32	29.85	29.67	Falling
9:30AM 12/11/69	12:00N 12/11/69	900	.36	.36	.35	29.78	29.70	Rising
12:30PM 12/11/69	3:00PM 12/11/69	1680	.80	.81	.79	29.81	29.79	Rising
3:30PM 12/11/69	9:00AM 12/12/69	500	.19	.20	.19	30.04	29.81	Rising
11:00AM 12/12/69	4:00PM 12/14/69	540 CFM	.18	.20	.12	30.17	29.70	Falling

TABLE 50 (continued)

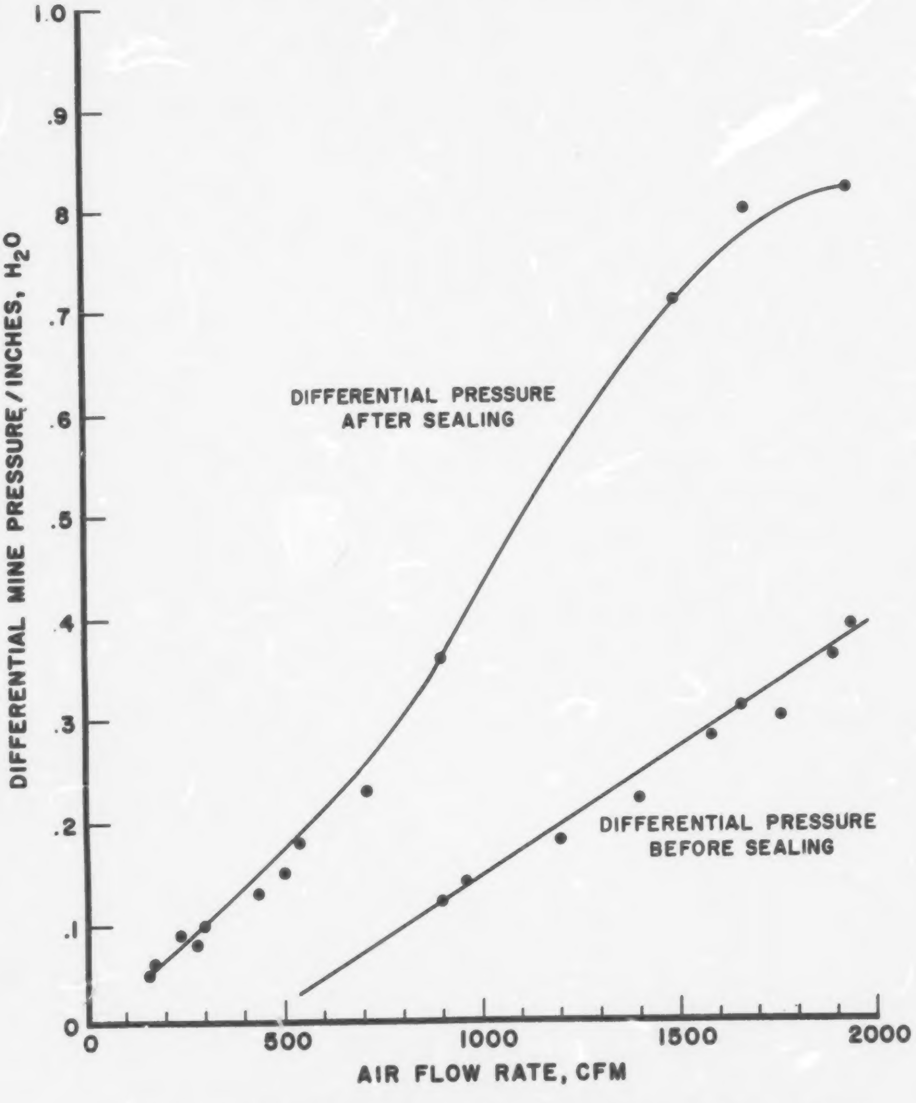
DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT VARIOUS AIR FLOW RATES AND BAROMETRIC PRESSURES

TIME PERIOD		AIR INJECTION RATE (CFM)	DIFFERENTIAL MINE PRESSURE (" H_2O)			BAROMETRIC PRESSURE (" Hg)		
FROM	TO		AVERAGE	MAXIMUM	MINIMUM	HIGH	LOW	TREND
10:30AM 1/5/70	2:30PM 1/5/70	710	.23	.24	.23	30.33	30.25	Falling
3:00PM 1/5/70	7:00AM 1/6/70	500	.13	.15	.15	30.25	30.19	Falling
7:30AM 1/6/70	4:00PM 1/6/70	1500	.71	.72	.70	30.19	30.00	Falling
9:00AM 1/8/70	2:00PM 1/8/70	500	.15	.16	.14	30.06	30.01	Rising
2:30PM 1/8/70	1:30PM 1/12/70	280CFM	.08	.11	.06	30.25	29.93	Falling
2:00PM 1/12/70	8:30AM 1/14/70	170CFM	.06	.08	.04	30.20	29.98	Rising
4:00PM 1/14/70	5:30AM 1/19/70	300CFM	.10	.12	.09	30.23	29.83	Cyclic
6:00PM 1/19/70	9:00AM 1/22/70	240CFM	.09	.10	.07	30.29	29.81	Cyclic
2:00PM 1/22/70	8:00AM 1/26/70	160CFM	.05	.09	.04	30.21	29.75	Cyclic

TABLE 50 (continued)

DIFFERENTIAL PRESSURE (MINE OVER BAROMETRIC) AT VARIOUS AIR FLOW RATES AND BAROMETRIC PRESSURES

TIME PERIOD		AIR INJECTION RATE (CFM)	DIFFERENTIAL MINE PRESSURE (" H_2O)			BAROMETRIC PRESSURE (" Hg)		
FROM	TO		AVERAGE	MAXIMUM	MINIMUM	HIGH	LOW	TREND
1:00PM 1/27/70	7:30AM 2/1/70	160 CFM	.06	.11	.04	30.17	29.81	Cyclic
10:00AM 2/2/70	5:30PM 2/2/70	200	.08	.10	.07	29.67	29.61	Cyclic
2:00PM 2/9/70	1:30AM 2/12/70	440 CFM	.13	.16	.10	30.03	29.79	Cyclic
3:00PM 2/17/70	12:00M 2/17/70	350	.10	.10	.10	30.08	30.03	Rising



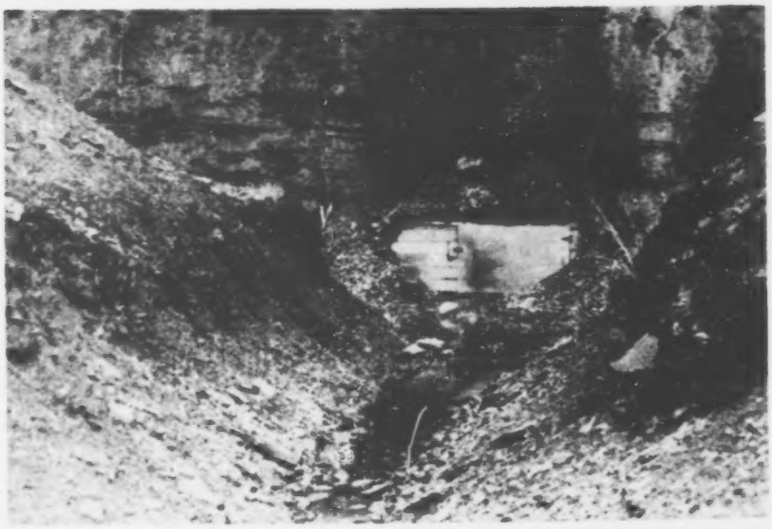
MINE DIFFERENTIAL PRESSURE BEFORE AND AFTER SEALING FRACTURE AREA

FIGURE 32

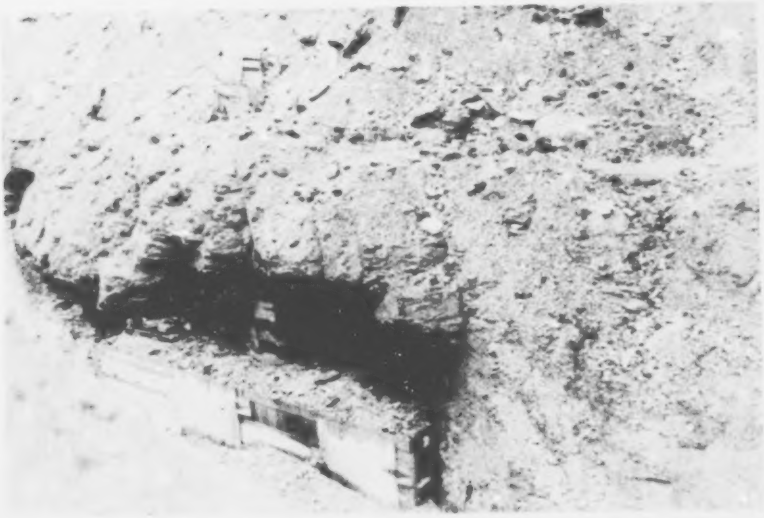
Section IV could be completed. The mine pressurization studies were to be continued at both the Whipkey and King No. 2 mine sites after adequate seals had been designed and installed in each deep mine opening. However, at the conclusion of the surface and sub-surface explorations, it was decided that it was not economically feasible to install seals in either of these two mines and, consequently, the mine pressurization study was terminated.

The findings of the sub-surface explorations at the Whipkey Mine site are quite significant in relation to the gas pressurization studies conducted at this site. At the initiation of this project, it was believed that the backfill at the Whipkey mine site had been completed to an average depth of approximately 15 feet above the coal seam. It was also believed that only two additional deep mine openings existed in the area of the backfilled strip mine. Removal of the backfill material at the base of the highwall revealed that the stripping operation had cut into the deep mine at numerous locations and that the average depth of backfill material over the coal seam was generally less than 3 feet (see Figures 33, 34, 35 and 36). Each of these numerous deep mine interceptions and fracture or subsidence areas is a probable point of air leakage at the Whipkey mine site, and cumulatively, probably accounts for the inability, to maintain a positive differential pressure within the mine.

DEPTH OF
ORIGINAL
BACKFILL

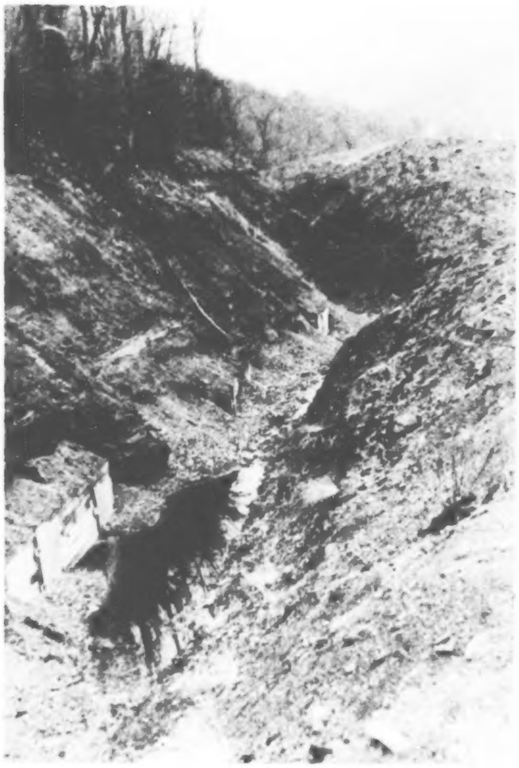


DEEP MINE OPENING INTO STRIPPED PORTION OF WHIPKEY MINE
FIGURE 33



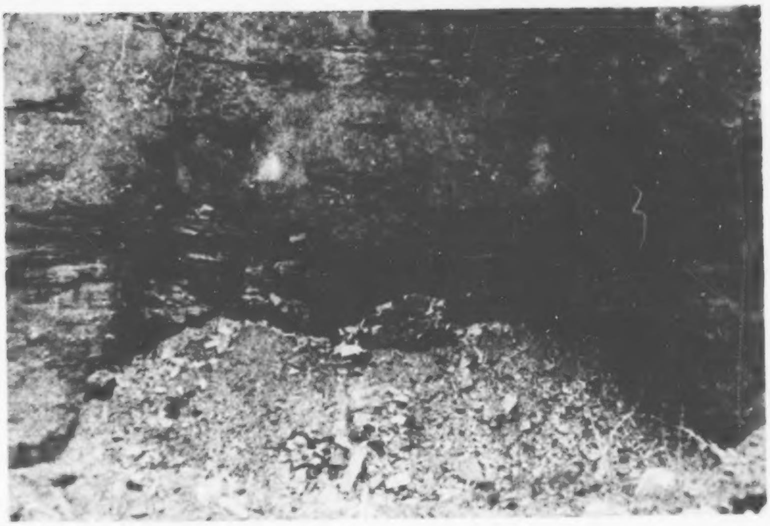
DEPTH OF
ORIGINAL
BACKFILL

DEEP MINE OPENINGS INTO STRIPPED PORTION OF WHIPKEY MINE
FIGURE 34



DEPTH
OF
ORIGINAL
BACKFILL

DEEP MINE OPENINGS
INTO THE WHIPKEY MINE
FIGURE 35



APPROX-
IMATE
LOCATION
OF
ORIGINAL
BACKFILL

SUBSIDENCE AREA IN STRIP MINED PORTION OF WHIPKEY MINE
FIGURE 36

SECTION VIII
LITERATURE SURVEY OF LEAK DETECTION TECHNOLOGY

A state of the art investigation and evaluation was conducted of existing technology which could be utilized in the location of leaks of mine atmospheres from abandoned deep coal mining operations. The information gained through such a review was important to the development of an effective leak detection program which was a requirements when establishing and maintaining pressurized, sealed, abandoned mines as an effective means of eliminating acid mine water discharges. The technology reviewed included chemical indicators such as smoke, dyes, gas and radiotracers, and odor; physical means such as ultrasonics; close visual observation; infrared photography; and aerial surveillance. Additional information was located after the conclusion of pressurization testing and incorporated into this report.

Some of the technology available has previously been successfully utilized in detection studies of various wastewater pollution problems. However, because of the unique dispersion effects of a gas or treated air atmosphere escaping from a mine, such technology has distinct limitations upon its use for such applications.

Most modern methods of leak testing use a search gas and a detector sensitive to it. However, such methods are usually applicable to testing the integrity of containment vessels, searching for underground pipe leaks, testing welds, and checking for leaks in bench scale test facilities. Because of the small amounts of gas utilized in such tests, comparative cost savings between various methods become significant unless the degree of accuracy or safety considerations warrant utilization of more expensive methods.

The most desirable qualities of a search gas selected for leak detection studies are that it is non-toxic, non-flammable and safe to handle. The foregoing should always receive consideration in order to protect the well-being of those required to perform the studies as well as giving consideration to the effects of a dissipating gas on the environment to which it is subjected. Various gases considered are now discussed in some detail.

A naturally occurring soil gas is methane. "Methane is given off by the pores of the coal in practically all mines, although often in amounts that can only be detected by careful analysis."[6] Methane is odorless, colorless, tasteless, non-poisoness and will not support life or combustion, but is explosive when mixed in proper proportions with air. Methane of itself could serve as a search gas under controlled conditions, however, its uncertain rate of production in a mine would need to be supplemented by injection of enough methane to blanket the mine and continually maintain the blanket. Methane detectors are in abundant supply since they are commonly used to continuously monitor safe working conditions in active coal mines. The overriding safety problems of potential explosive conditions and inability to support life make it unattractive as a search gas since operating costs would be considerable to overcome the safety hazards involved for those required to work with the gas.

Carbon dioxide was considered to have the desirable characteristics of being non-explosive and non-toxic as well as relatively inexpensive, even less expensive than helium which will be discussed later. However, the most detrimental characteristic to further serious consideration of the gas was the fact that it is heavier than air. Commonly, a blanket of carbon dioxide normally lays on the mine floor and produces resultant displacement of the lighter air. This characteristic would make it very difficult to diffuse enough carbon dioxide to be detected throughout the entire void of a mine.

Carbon monoxide was considered from the standpoint that it can be detected in low concentrations (circa 10 ppm). Carbon monoxide has the obvious disadvantage of tieing up hemoglobin in the blood stream of anyone exposed to it. It is anticipated that exhaust gases from the blower equipment could be piped into the mine as a means of introducing carbon monoxide as the search gas. However, most internal combustion engines produce a low percentage of carbon monoxide which would require blowers to be run for extended periods of time to produce a sufficiently detectable concentration of the gas. "A number of carbon monoxide detectors are commercially available, and ampoules can be used with conclusive results if the carbon monoxide concentration is strong enough."[7] Because of the high levels of carbon monoxide required to accomplish this means of leak detection, safety consideration would be of prime importance for all workers in operating and maintaining blower equipment used to blanket and pressurize a mine with this search gas. Safety would require the provision of a portable resuscitation unit near the blower to protect the workers, since the deleterious effects of carbon monoxide can be reversed if oxygen is given to an individual.

Hydrogen has excellent properties for a gas leak detection survey. It is light, relatively inexpensive, non-toxic and easily detectable with numerous commercially available, inexpensive detection devices. Hydrogen was ruled out as the best selection of a search gas because of the extreme hazardous explosive property of the gas. Should the proper hydrogen-oxygen mixture be formed by the injection of hydrogen into a sealed mine, disastrous consequences could be experienced by the introduction of the slightest spark or flame into the area.

With the portable gas detectors now available, many other gases can also be monitored. "In the medium range of sensitivity, the most attractive search gas/detector combination is now the halogen-containing gas which is detected by its stimulation of electron emission from a tungsten filament (the 'halide tector'). The detector is robust and cheap and the gas may be of the harmless freon type." [8] Freon-12 can be detected in as low a concentration as 14.2 grams (1/2 ounce) per year, but is is expensive and has a threshold limit of toxicity (maximum allowable concentration) of 1,000 ppm. Introduction of such a gas to a mine might easily produce such a threshold limit around the blower and mine entrance.

Vinyl chloride could also be used for such detection studies, but it is also flammable and toxic (maximum allowable concentration - 500 ppm). The same is true of methyl chloride.

Other gases which may easily be detected include butadiene, sulfur hexafluoride, propane, argon, nitrous oxide and anhydrous ammonia. All of these gases have been discarded from serious consideration for a mine gas leak detection study primarily because of their hazardous characteristics of flammability and/or toxicity and their excessive cost considerations.

"Many commercially produced instruments are now available with a high degree of reliability. Helium has all the desirable qualities of a search-gas (except extreme cheapness). It is inert, harmless and does not occur in significant quantities in the air or in any normal material. Because of its low atomic weight, it is second only to hydrogen in diffusing through small fissures." 8 Helium was selected as the best search gas for mine leak detection studies primarily because it is relatively inexpensive, lighter than air, and safe to use (non-explosive and non-toxic), and small, portable, inexpensive detection equipment is readily available.

A cost estimate is presented of the requirements to flood a mine with a detectable concentration of helium. The figures are presented with the implied understanding that the helium would be introduced slowly to the mine at a rate less than its diffusion coefficient. Costs are presented with respect to the Whipkey and King mines covered by the study.

Whipkey Mine

Area - 50 acres

Volume - 4.57×10^6 ft^3 = 1.29×10^8 liters

King Mine

Volume - 2.3×10^6 ft^3 = 6.514×10^7 liters

Three volumes of gas are required to flush each mine

Whipkey Mine - 3.882×10^8 liters

King Mine - 1.9542×10^8 liters

The helium requirements and associated cost for the Whipkey Mine are presented as an example:

average molecular weight of air = 29 grams

1 mole of air at S.T.P. = 22.4 liters

$$\text{density of air} = \frac{\text{average molecular weight of air}}{\text{mole of air}} =$$

$$\frac{29}{22.4}\ \frac{\text{grams}}{\text{liters}} = 1.29 \text{ grams/liter}$$

weight of air = volume of air x density of air

(entire mine)

weight of air = $(1.294 \times 10^{8}\ l)(1.29\ g/l) = 1.669 \times 10^{8}\ g$

helium required in mine for an air mixture of 10 ppm helium

$$\text{Helium weight} = \frac{\text{weight of air} \times 10}{1 \times 10^{6}} = \frac{1.669 \times 10^{8}(10)}{1 \times 10^{6}} =$$

$$1.669 \times 10^{3}\ \text{grams}$$

$$\text{Helium volume} = \frac{\text{helium weight}}{\text{helium density}} = \frac{1.669 \times 10^{3}\ g}{.1769\ g/l} = 9435\ l$$

$$\frac{9435\ l}{28.32\ l/\text{cu.ft.}} = 333\ \text{cu.ft.}$$

flushing the mine with three volumes of the foregoing air-helium mixture would require 999 cu. ft.

helium is commercially available at 220 cu. ft./\$35.00 or \$.159/cu. ft.

the cost of helium to flush the mine would be \$158.84

Detectors are readily available to determine the presence of helium concentrations in air. An example of such a device is a hand-held sniffer (approximately \$250.00/unit) made by Matheson which passes 50 cc/min. mass air flow through the detector and is able to detect the following:

Freon in concentrations of 9×10^{-5} cc/sec

Hydrogen in concentrations of 3.6×10^{-5} cc/sec

Helium in concentrations of 5.4×10^{-5} cc/sec

It is anticipated that slight pressurization of a mine by use of a blower to inject an air-helium mixture as previously mentioned would result in the air mixture flowing through all fissures. It is also expected that gas dispersion effects should cause the helium to seek out fissures without diffusing throughout the entire mine atmosphere.

In general, a fissure through rock strata could be leak proof with respect to water or liquid contact, but not necessarily to a gas. Water could seal small holes due to its surface tension capabilities and/or because of the deposition effect of water carrying various types of soil fines. Gas, however, would have a tendency to break through any seals caused by surface tension and tend to keep fissures clear of fines.

Smoke indicators are probably one of the most feasible methods of leak detection, since they can easily be visually observed issuing from an opening. However, attempts to use titanium tetrachloride, which produces titanium dioxide smoke, met with little success. The most probable reasons for the failure of this particular smoke technique was that the mine in which it was injected was free-breathing at the time the smoke was introduced (at one seal the mine was observed to be inhaling and exhaling smoke) and insufficient quantities of the gas were produced to fill the entire void of the mine.

An advantage for the use of smoke bombs is that they are very inexpensive, producing one million cubic feet of smoke from one can for approximately $16.00. Limiting factors to the success of smoke bomb application are the fact that smoke will condense on wet surfaces (mine walls are often damp due to ground water seepage), wind shifts on the surface may shift smoke clouds emanating from the fissures to other areas, and the earth may act as a filter to remove smoke particles before they reach the surface, if the fissures do not directly connect to the mine shaft.

In addition to limitations imposed by the rock structure itself, weather may also be a critical factor in terms of determining mine gas leaks utilizing any one of various gases or smoke. Frost in the ground is certainly a factor to contend with since a shallow layer of frost has a pavement-like effect over any points of leakage which tends to cause a leak pattern enlargement. "Deep frost may create addition effects."[9]

Another indicator technique considered was the use of a chemical defoliant injected into a mine by a blower. This, in effect, would place another type of specialized atmosphere within a mine which would then be expected to filter its way through any cracks or fissures to the surface. At the area around each exit point, any existing foliage would eventually be deprived of sufficient oxygen to sustain growth and an aerial or walking survey of the area would reveal such conditions. The primary effects of gas on plants is due to the carbon monoxide content of the gas which gradually displaces the normal soil atmosphere which contains vital oxygen necessary to the normal functioning of a healthy root system. "The displacement of the normal oxygen from the soil also unbalances the soil bacterial population, resulting in chemical and physical changes in the soil that reduce its ability to support life."[10]

An example of a defoliant and its effect can easily be seen in natural gas, which may occur under the right natural conditions to cause the destruction of plant life. "Commercial natural gas is basically methane (CH_4), non-toxic, colorless vapor containing trace amounts of heavier hydrocarbons such as ethane, propane, butane, pentane, and hexane, plus an odorant material. When this vapor spreads out in the soil from an underground leak, it displaces the normal soil atmosphere that contains oxygen. When this occurs, the soil is no longer able to support plant life."[10] Natural gas, and in turn other similar gases, has a drying effect since it has practically no moisture content. It also has a spreading effect through soil since it is lighter than air. The rate of spread is a function of the type of soil; light porous soil will allow free movement while clays retard or resist upward movement. Generally the pattern of spread is irregular but generally upward; however, other factors effecting the spread include the size of the leak, pressure effects on flow and the depth of leak.

Although the foregoing technique has very positive effects in the areas of leaks, it can be seen that considerable time must be allowed to permit the chemical defoliation processes to work. Also care must be exercised to prevent contamination of water supplies as well as soil pollution. " 'Soil pollution' may be defined as 'the presence of an odorous toxic gas in a soil in a concentration sufficient to change the atmospheric characteristics of the soil in a given area, the resulting effect of which is hazardous, destructive or a general nuisance.' "[7]

Considering the far reaching effects of the introduction of induced gases upon soil, the environment in general and the whole life cycle, this technique of gas leak detection should not be commonly used. It should be relegated to controlled conditions and with the highest consideration for the environment.

Consideration was also given to another more exotic indicator technique of gas leak detection, that of a distinctive odor emanating from cracks or fissures. There are many compounds available which will produce a distinct noticeable odor from minute concentrations injected into an air atmosphere. Ethyl and methyl mercaptan are two of the best known and most widely used of the odiferous compounds available. A disadvantage of this approach is that mercaptans are both toxic and flammable in high concentrations producing a safety hazard to those conducting such an operation. Also, mercaptans as well as other powerful odor producers will quickly blind human and animal olfactory nerves to the degree that the observer will be smelling the odor in all areas, even where it is not present. It was intended that dogs would be trained and used to trace the scent of a particular compound to its source(s).

To the extreme when considering the foregoing from a biological perspective, both male silkworms and male monarch butterflies can detect the scent of a female from many miles away. Such scent compounds have been synthesized in the laboratory, but of course a person can readily imagine the expense and difficulty involved in putting such a method into practice.

Radioactive tracer gases were considered as vital elements in a leak detection technique, and many such gases are available. One gas investigated was Radon; however, it was determined that it is extremely hazardous to use. Its maximum allowable concentration in air is only 7 x 10^{-11} ppm. "This material can cause cancer, particularly of the lungs. It is a very serious and disabling toxic harard."[11]

Within the application of a radioactive search technique, there is a distinct disadvantage in measurement due to the half-life of the gas. "Krypton 85 is a suitable gas chemically inert and with a radioactive half-life of 10.6 years"[8]. Small leaks can be detected in the same way as helium is measured by a mass spectrometer, and with about the same sensitivity.

Radioactive isotopes of some inert gases such as Argon can be used, but most of these gases have very short half-lives. Such gases must be purchased and irradiated on site to be fully effective in detection studies. Half-life is definitely a critical factor in determining what radioactive gas to use for a leak detection study. A very short half-life, as in the case of inert gas isotopes, means that the gas must be used very shortly after irradiation or it will not be effective. A longer half-life has the inherent danger of contaminating the surrounding streams and atmosphere with radioactivity for an extended period of time. There is also the danger with any radioactive material of exposing operating personnel to dangerous concentrations of radioactivity.

In order to pursue radioactivity as a means of detection, a geiger counter should be purchased and then contact should be established with a gas supplier concerning the gas mixture to be used with the counter. Mathieson is a common source of supply for a complete line of such mixtures which are marketed under the name "Geretron". Such mixtures are basically fluor-chloro-ethane or methane mixtures, ranging in cost from $100 to $300 per 220 cu. ft. cylinder.

Ultrasonics may also be used as a gas leak detection technique, however, it is basically limited in usefulness to pressurized systems. The basis for detection is dependent on a jet of escaping gas producing a louder sound than other surrounding noises, which serves as a directional guide. Ultrasonic leak detectors such as Hewlitt-Packard Company Delcon Division instruments utilize earphones to pick up the hissing sound "frequency" from the point of escape which becomes louder as you travel toward the leak location. "The battery powered device electronically translates nigh-frequency acoustic energy released by the operation of mechanical and fluid power apparatus, defective pressure and vacuum and electrical systems." 12 Ultrasonic detection is best suited for duct leak applications and its degree of sensitivity is not high; therefore, it is not recommended as an effective leak detection device for mine applications.

Close visual observation is another method of leak detection which can be considered. To simplify such observation, a color additive to the gaseous system will permit much easier and more positive identification. A product named Saftigas [13] promises to facilitate leak detection observations. It is a leak pinpointing agent which adds color or sight perception ability to invisible gases. It is easily metered into a system in the same manner as odorants are presently added to gases, and can be recognized easily by sight because of the white emanating from points of escape.

Another aspect of visual observation of escaping gases is the ability to determine their presence by the shadow or heat wave effect of the gases. When looking across a hole, with the eye close to the surface of the ground, escaping fumes will appear similar to heat waves above a radiator. "On a sunny day, escaping gas will cause shadows on the pavement or on a piece of white paper held perpendicular to the surface with the hole between the paper and the sun." [9] Although the foregoing describe valid visual observation techniques, there are severe limitations to to their use in mine gas leak detection since leaks may not be sufficiently large to determine a heat wave effect over acres of a potential leak area, weather and terrain are most likely not conducive to such a study, and areas of points of leakage almost need to be preliminarily determined for application of such techniques.

Infrared photography is another detection technique worthy of consideration; however, it has definite limitations to its use and is normally considered to be an integral component of aerial surveillance techniques subsequently discussed. When infrared photography is performed from a plane, a scanning mirror is employed to pick up infrared energy from a ten foot diameter spot on the ground at any instant, with the mirror moving right to left perpendicular to the movement of the plane. Such movement produces a scan of the strip of land over which the plane passes which is transferred through a parabolic optical system to an infrared detector cooled by liquid nitrogen. The detector, in turn, energizes a light proportioned in intensity to the signal. Infrared film passing under the light is exposed and produces a negative-like picture. This type of instrumentation is capable of detecting temperature differences of a fraction of a degree. "For that reason, it doesn't work too well during daylight hours because reflected solar radiation masks out weaker radiation from warm objects. So IR surveys are run at night." [14]

Application of infrared photography to mine gas leak detection can take on several aspects. If a defoliant is injected into the mine and causes deleterious effects on surface foliage around points of leakage, aerial infrared photography can distinguish diseased plants from healthy plants even before a trained botanist on the ground could determine same. Since infrared film is theoretically sensitive to a few tenths of a degree temperature difference and mine temperature stays at a fairly constant temperature on a cold or hot day, infrared photography could possibly detect the flow of mine air out of leak points to the atmosphere. However, a similar study was performed by the Bureau of Mines with relatively poor results. The reason for limited success is that the right atmospheric conditions must prevail for air to continuously flow out of the mine. If an artifically induced and controlled pressure was produced in the mine by a blower, the problems associated with natural atmospheric pressure would most likely be resolved.

A wealth of information is available on the details of infrared photography; a particularly good reference source is Kodak's Applied Infrared Photography. Film is readily available. Some distinct limitations of this technique of detection include: small temperature differences are not easily distinguished, resolution of various sized objects is poor at low sensitivity (temperature) levels, and at high sensitivity, hot sources are masked out by large warm sources.

Climate conditions are critical for infrared photography since the best conditions for photography may be poor flying conditions for small aircraft. A bright summer day perfect for flying, will present all types of photographic problems. The best infrared conditions would be a snowy day (the snow gives the earth an almost isothermal condition), with photography being performed either in cloudy conditions or at night to minimize sun reflections. A cold day would produce a maximum temperature difference between the atmospheric and mine air, as well as minimum foliage interference conditions. The foregoing along with the increased cost considerations for the availability of equipment (camera and airplane) and period of rental (least expensive approach) are the major considerations in selecting this detection technique.

There are instruments available which work just like laboratory spectrometers, but are portable and can be used for ground and aerial surveillance. They will pick up the wavelengths emitted by many gases including CO, CO_2, CH_3, H, etc., and give photographs of a topographical area showing concentrations of the specific gas being monitored. These instruments could be used to detect mine leaks, but the economics are prohibitive. Minimum equipment cost runs approximately $3,000, and there is still the need for aerial surveillance and blower equipment to pressruize the mine with the tracer gas. This method will not pick out specific leaks, but will generate "density" maps, requiring the assumption that the leak is in or around the area of maximum gas concentration. Considering the foregoing, a leak detection study could be performed with infrared or helium detection devices, with the same results as a spectrometer, and at a fraction of the cost.

Aerial surveillance as a detection technique is most commonly associated with infrared photography. Originally this technique was developed for use in the war effort simply to distinguish between camouflaged areas and normal vegetation, soil and structures. Aerial surveillance has had wide acceptance in geothermal applications. "Through aerial photographic interpretation techniques it is possible to identify landforms and to estimate soil texture and drainage conditions and depth to bedrock conditions. The trained air-photo interpreter observes and analyses the topography, drainage pattern, erosion, photo tone pattern, and vegetation and land use of the area shown on the air photos." [15] Aerial photography has received considerable use for mapping as well, and more recently has been used extensively for water pollution surveys, air pollution studies. "Aerial photography has been used for nearly a century. Recent developments in aerial photography, such as color film, color infrared film, and multiband photographic systems, have greatly increased the amount of useful information obtainable from aerial photographs. For example, it is possible, through the use of color infra-red film, to distinguish between healthy and diseased plants, even in cases where such differences may not be visibly detectable." [15]

Aerial surveillance could be utilized in connection with the use of a smoke indicator injected into the mine in order to pinpoint the various leakage points. However, it is often difficult in such aerial smoke surveys to distinguish plume particles from normal background clutter and in some cases visibility may be impaired because the plume itself, preventing the determination of precise locations of plume services.

"So highly developed have become the instruments, computers, plotters, and photographic equipment and optics, and so specialized the operators and photogrammetrists, that almost all phases of aerial photography are now performed under contract by aero-survey companies." [16] However, there are uses to which aerial photography can be applied which do not require such precision. In such instances, aerial surveillance affords considerable cost savings compared with forms of ground surveys.

Another more exotic detection device which was given cursory consideration was seismographic methods. Soiltest, Inc. [17] makes a complete line of seismographic equipment which is designed for underground testing. Such equipment induces pressure waves into the earth and then records the reflected signals picked up by a sensitive sensing device. Based on the time required for a signal to return, it can be determined what form the earth structure takes and whether any voids are present and where they are located.

There are definite limitations to such a technique. "First, all the reflective seismic methods require a subsurface which is approximately linear over the distances of the order of the cable length. If this condition is not met, velocities and depths cannot be predicted with any accuracy, nor are there any currently existing methods for circumventing the problem." [18] With respect to the foregoing, it is highly probable that this technique would be able to determine the location of the mine shafts themselves, but not necessarily be so finely sensitive to determine the location of cracks and fissures extending to the surface.

In view of the findings of this literature survey, infrared photography, smoke detection, and the injection of tracer gases such as helium with subsequent detection by hand-held "sniffers" were deemed the most feasible methods of locating leakage points from mines.

SECTION IX
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